

the magazine of aerospace technologies / JAN. 1960

*Rec-1/25/60
mro*

space aeronautics



CHICAGO PROPERTY OF
MIDWAY LAB

SPECIAL REPORT:

undersea weapon systems



INFRARED...

**new and important
uses from *Crosley***

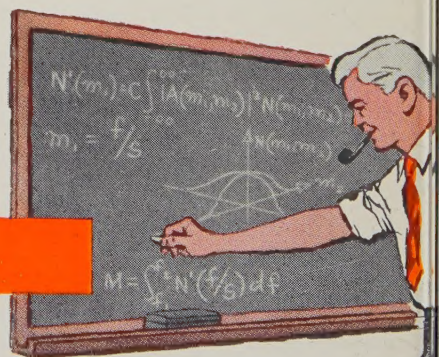
Infrared—which in World War II gave the expert marksman the power to see in the dark—now holds even greater promise. It may serve to provide early warning of approaching ICBM's if they are launched.

Infrared's singular use in World War II triggered a tremendous postwar effort to find other uses for its unique features. This effort, to which Avco's Crosley Division is a major contributor, has produced many applications in both industry and defense to which infrared is ideally suited.

Because they are so important to the national defense effort, most infrared research programs are classified as secret. But in general, Crosley's work in the field points toward new breakthroughs and conspicuous contributions in searching, tracking, anti-ICBM detection, airborne early warning and defense systems, reconnaissance, surveillance, anti-submarine warfare and passive ranging.

As a result of its progress in these areas, Crosley's team of infrared specialists—one of the largest in the country—is gaining the respect of a growing number of contractors.

For more information, write to: Vice President, Marketing-Defense Products, Crosley Division, Avco Corporation, 1329 Arlington Street, Cincinnati 25, Ohio.

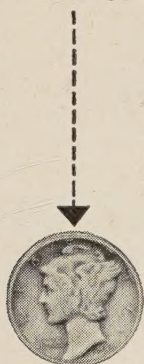
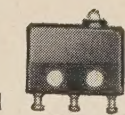


ENGINEERS AND PHYSICISTS

Excellent career opportunities are available for all levels of Engineers and Physicists specializing in: Optical Systems and Instrumentation, Infrared Systems, Physics of Infrared, Electronics with emphasis on Transistor Circuitry, Infrared Detectors and Components, Infrared Measurements and Mechanical Design. For further information, contact: Director, Technical and Scientific Personnel, Avco/Crosley, Dept. -10, 1329 Arlington Street, Cincinnati 25, Ohio.

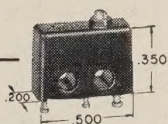
Avco **Crosley**

SMALL ENOUGH



TO HIDE BEHIND A DIME

Smallest of precision snap-action switches ... 1/2 kw capacity



CASE SIZE: .500" x .200" x .350"—ten to the square inch.

WEIGHT: 1 gram—28 switches to the ounce.

ELECTRICAL RATING: 28 vdc: 7a. resistive, 4 a. inductive—sea level; 2.5 a. inductive—50,000 ft.; 4 a. motor load, 2.5 a. lamp load, 24 a. max. inrush. 115/230 vac: 60 to 400 cycles: 5 a.; 15 a. inrush.

MECHANICAL LIFE is in the millions of operations.

The case of the 1SX1 has two through holes that accept #2 screws. One hole is slightly elongated to facilitate mounting.

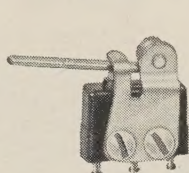
The 1SX1 operates dependably in temperatures from -65°F to +250°F. Operating force is controlled and predictable within 3 oz. to 5 oz. limits.

For more information about this important switch, ask for Catalog 63.

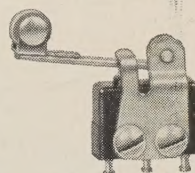
MICRO SWITCH field engineers will be glad to provide application assistance and give you full information on this sub-subminiature switch and its actuators. Call your nearby MICRO SWITCH branch office.

Now offered with six actuators

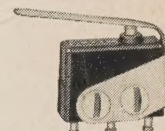
These actuators are offered in four basic designs and, in addition, two reversed actuators are offered which provide lower free position and reduced pre-travel.



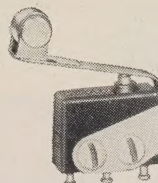
Pivoted lever actuator



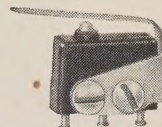
Pivoted roller lever actuator



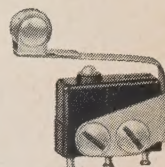
Leaf actuator



Roller leaf actuator



Reverse leaf actuator



Reverse roller leaf actuator

MICRO SWITCH... FREEPORT, ILLINOIS

A division of Honeywell

In Canada: Honeywell Controls Limited, Toronto 17, Ontario



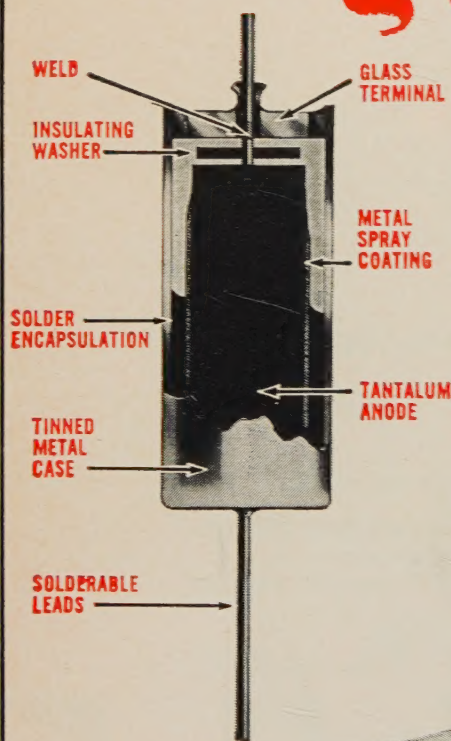
Honeywell

MICRO SWITCH Precision Switches

Write in No. 2 on Reader Service Card at start of Product Preview Section

ASTRON SOLID TANTALUM CAPACITORS

rugged



WITHSTAND
vibration
TO 2000 CYCLES
AND 35 G'S.

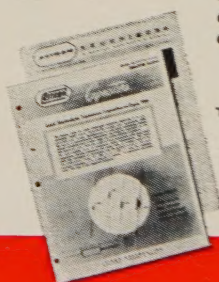
In the construction of the Astron Tantalum Solid Electrolyte Capacitor, the tantalum anode is firmly embedded in solder and solidly fixed in the case. There are no external welds, and the tinned leads can be bent adjacent to the case.

Production capacitors are regularly tested in accordance with MIL-STD-202A, Method 204, test condition B, to 2000 cycles and 15 g's.

Astron Solid Tantalum Capacitors have withstood 200 g acceleration and 150 g shock tests.

- 125°C operation.
- Rugged construction.
- Capacitance stability.
- Subminiature.
- Dry, solid construction.
- Meets MIL specifications.

FOR COMPLETE INFORMATION WRITE TODAY FOR BULLETIN E-675A AND FOR ASTRON'S DESIGN ENGINEER PUBLICATION, TECHNIQUES, VOL. 59, NO. 2



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255 Grant Avenue
East Newark, New Jersey

SPECIALISTS IN CAPACITOR MINIATURIZATION

space & aeronautics

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Write in No. 3 on Reader Service Card at start of Product Preview Section

SPACE/AERONAUTICS

Portraits
of
PERFORMANCE



Two rousing tributes to the performance reliability of CECO products are the remarkable records being compiled by the jet airliners pictured above in "gallery display"—the Boeing 707 and Douglas DC-8.

Main fuel pumps for the Pratt & Whitney Aircraft engines powering each were engineered and precision-produced by Chandler Evans. Significantly, during the first exciting year of U.S. commercial jet operation, CECO pumps took part in every single service mile flown by either type of aircraft.

If pictures of missiles and aircraft which are airborne with CECO products actually *were* exhibited in a gallery, the section devoted to pump applications would be an impressive one. In addition, space would have to be set aside for future portraits, since right now . . . at Chandler Evans . . . a number of important pump design and development programs are underway.

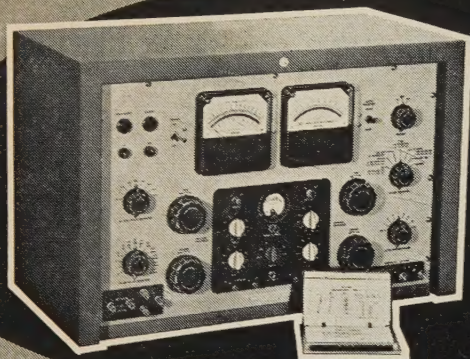


CHANDLER EVANS CORPORATION
West Hartford 1, Connecticut

Interesting, informative literature on many CECO products is yours for the asking. Please address your request to Dept. 10.

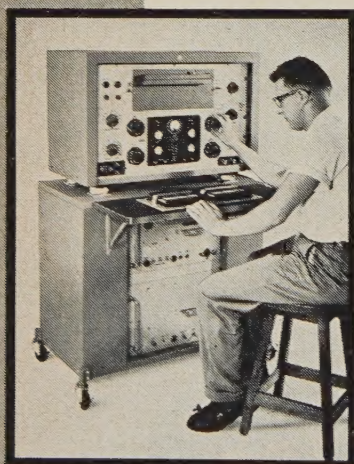
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from Instrument Calibration HEADQUARTERS



The
proven
method of
maintaining
Accuracy

Improved reliability and sustained quality control, through periodic calibration of test instruments, can be achieved by semi-skilled personnel using either of these self-contained standards.



Model 829 provides full-scale calibration accuracy of 0.5% for both AC and DC meters over ranges from 0.25 millivolt to 2000 volts and 2 microamperes to 20 amperes. AC calibrations can be performed from 50 to 400 cps., depending on line frequency used, or unit can be driven by optional variable frequency power supply. Automatic protection for both operator and instrument under test is provided by interlocks and high voltage discharge circuits. Net price \$2,650.

Model 829A provides full-scale calibration accuracy of 0.25% for AC and DC meters over same ranges as Model 829. Horizontally mounted standard meters are employed, and a fluorescent light is provided for proper illumination. The illustration shows the Model 829A mounted on the Model 10 Test Equipment Cart with the standard meters recessed into a drop-leaf work shelf. Mounted inside the Cart is the Model 500 Variable Frequency Power Supply which will supply any frequency for calibration from 50 to 400 cps., plus excellent line regulation. Net price of Model 829A with special Weston meters is \$3,150.

Performance is rigidly guaranteed.
Prices are f.o.b. Boonton, N.J.
and subject to change without notice.



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DATA

For additional information, including application data, write or phone DE 4-3100. Demonstrations available by local representatives.



**Radio Frequency
LABORATORIES, INC.**
Boonton, New Jersey, U. S. A.

cover story



A sub, a missile, and radiated energy against the background of the ocean environment—that's how Weimer Pursell, this month's cover artist, symbolizes the scope of SPACE/AERONAUTICS' special report on undersea weapon systems (beginning on page 39). The lines of radiation show the deflection of acoustic waves. Two of the bothersome peculiarities of the ocean are also shown: its extremely irregular bottom and its sharp temperature changes. Among the features of our special report that you won't want to miss are an industry survey on undersea-weapon-system development, state-of-the-art reports on detection, communications, guidance, propulsion, and hydrodynamics, and the *pièce de résistance*—a four-color pullout map of the undersea environment in the North Atlantic.

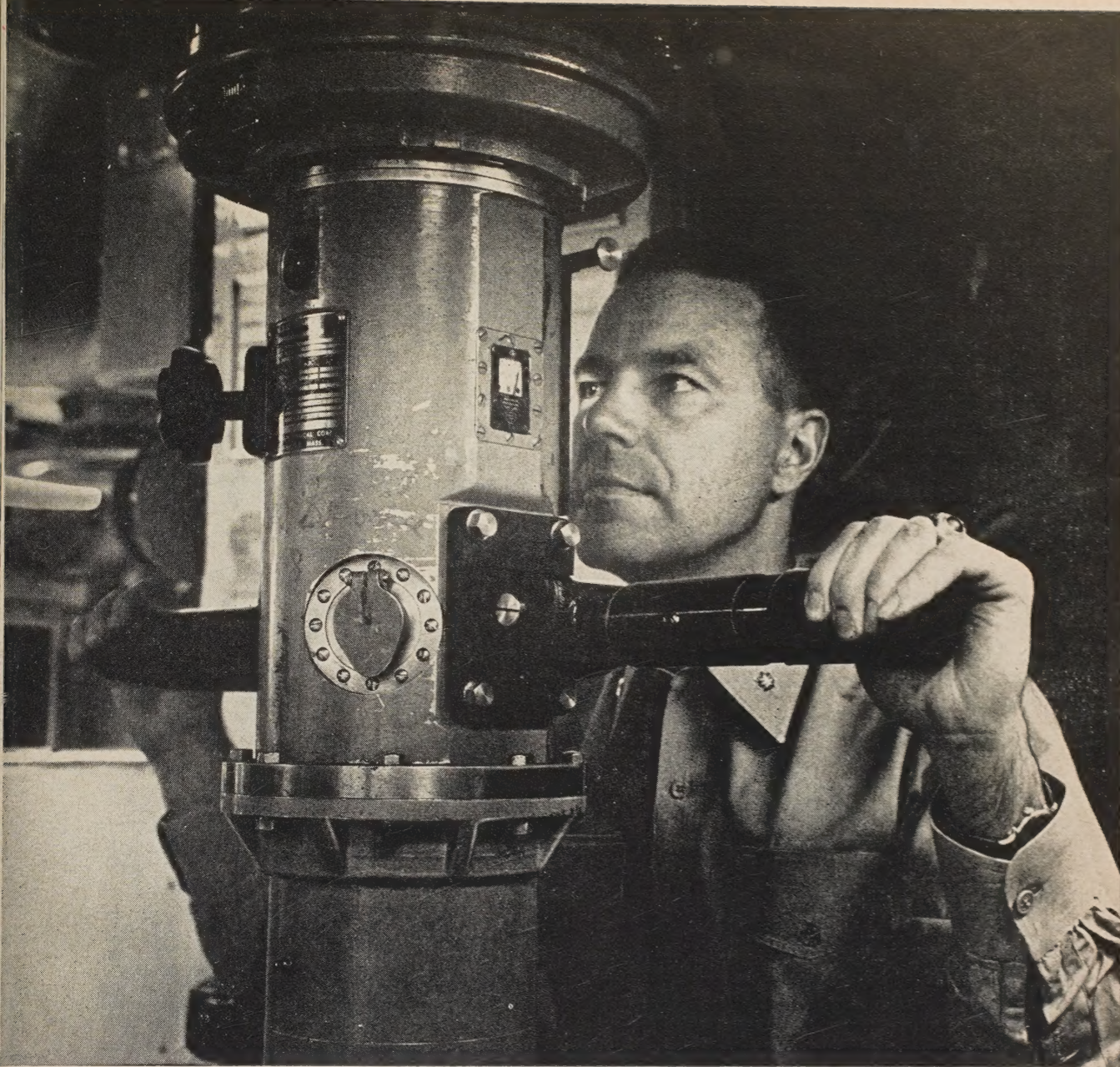
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COUNTDOWN...at full fathom five

One day, a new fleet weapon system will be on-station beneath the ocean surface—ready to hurl retaliatory missiles toward strategic inland targets with pinpoint accuracy. This new weapon system will be part of the Navy's Polaris Fleet Ballistic Missile Program.

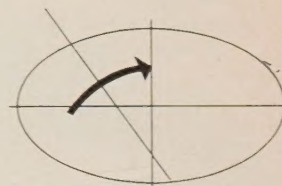
Though new in concept, the Polaris program makes full use of the precision Shipboard Inertial Navigation Systems (SINS) developed and produced by Autonetics for the United States Navy.

System design and components of earlier

autonavigators have proved reliable in an Air Force supersonic missile, aboard the Navy's surface ship *USS Compass Island*, and on the *USS Nautilus* and *Skate*.

Advanced Autonetics' Shipboard Inertial Navigation Systems—like those to be used by the *USS George Washington*, the first Polaris-carrying submarine—will provide the critical missile alignment data to insure effective missile launching. SINS emits no tell-tale signals...requires no receipt of external transmission at any time.

DID YOU KNOW?



The flattening of the earth at the poles can result in a navigational error of almost eleven nautical miles if not taken into account.

Inertial navigation by Autonetics

A DIVISION OF NORTH AMERICAN AVIATION, INC., DOWNEY, CALIFORNIA • REGIONAL OFFICES: WASHINGTON, D.C. AND DAYTON, OHIO
INERTIAL NAVIGATION/ARMAMENT CONTROL/FLIGHT CONTROL/COMPUTERS AND DATA PROCESSING

Technical Management

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Special Report: UNDERSEA WEAPON SYSTEMS

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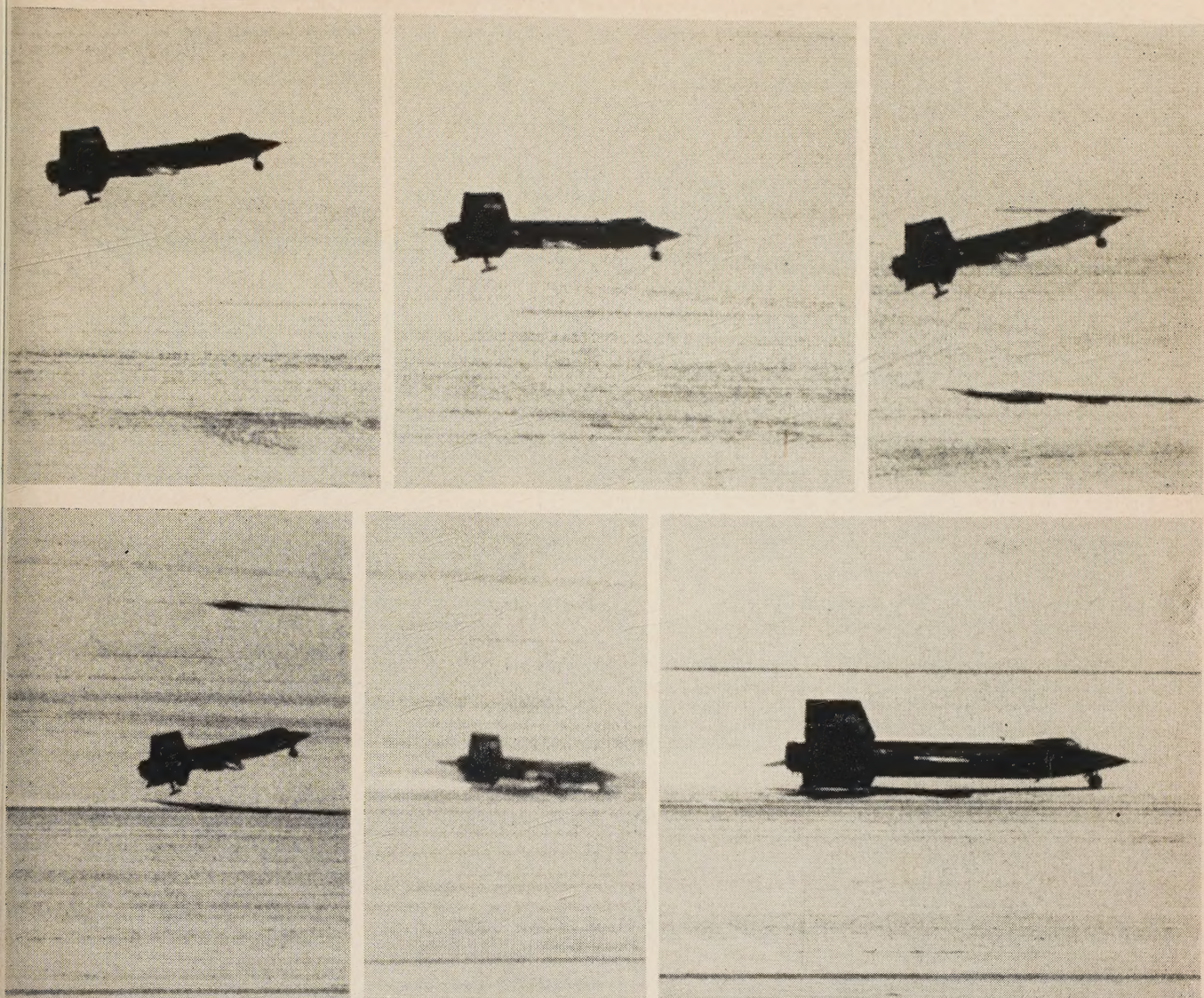
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The editorial content of Space/Aeronautics is regularly examined for readability by Robert Gunning Assoc., consultants in clear writing. These consultants meet periodically with the editors and discuss comparative readability ratings.

B.F. Goodrich

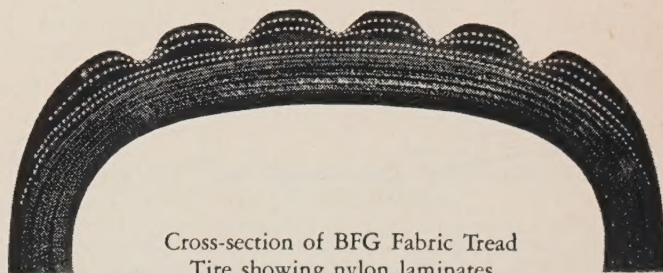


Fabric Tread Tires invented by B. F. Goodrich help land X-15

When the North American X-15 comes in for a landing, the B.F. Goodrich Fabric Tread Tires on its dual nose wheel touch down at about 200 mph. As X-15 comes to a stop, these special tires must withstand tremendous friction and heat build-up. Yet they can take this rugged pounding because nylon laminates are sandwiched right into the tread stock. These laminates reduce distortion under load, equalize modulus between tread and carcass and check "shock wave" formation.

The same construction now goes into BFG tires for today's newest commercial jets. For further information on these and a variety of B.F. Goodrich products you can use in space, in the air and on the ground, write to *B.F. Goodrich Aviation Products, a division of The B.F. Goodrich Co., Dept. AW-119B, Akron, Ohio.*

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Cross-section of BFG Fabric Tread
Tire showing nylon laminates

B.F. Goodrich
aviation products



in this issue

Here's a quick rundown of the technical information offered in the articles in this issue. You can also use these article abstracts to build up your own permanent record for reference in the future—just clip them, paste them up on standard three-by-five cards, and file them.

Special Report:
Undersea Weapon Systems

Astia code: 31-4
Your code:

New system concepts developing for undersea weapons

Analysis of trends in underwater weapon system development and their importance for the aerospace industry. Gives examples of typical advanced system concepts. Proposes aircraft-systems approach to overall problem.

by Victor de Biasi, Associate Editor

space/aeronautics 33/1 (Jan. '60)

p. 43

Special Report:
Undersea Weapon Systems

Astia code: 19-3
Your code:

State of the art: guidance and navigation

Report on some major design trends and problems in FBM sub and weapon guidance. Autonavigator systems are covered and potential sub navigation techniques are briefly analyzed. Wire and preprogramed torpedo guidance and homing are discussed.

by Bernard Kovit, Associate Electronics Editor

space/aeronautics 33/1 (Jan. '60)

p. 64

Special Report:
Undersea Weapon Systems

Astia code: 31-4
Your code:

Catching up with the submarine

Analysis of what makes the nuclear submarine such a potent weapon and how our technical means of combating it are limited. Generally reviews submarine's effectiveness as a weapon, present detection techniques and their characteristics, and the effect of the ocean on systems operations.

by Paul Cohen, Sperry Gyroscope

space/aeronautics 33/1 (Jan. '60)

p. 48

Special Report:
Undersea Weapon Systems

Astia code: 21; 27-2, -3
Your code:

State of the art: propulsion

Review of latest concepts of underwater propulsion for submarines and missiles. Analyzes underwater analogs of airborne designs, including ramjets, pulsejets, and turbojets. Also covers highly advanced concepts such as hydromagnetic pumpjet and thermionic powerplants.

by Victor de Biasi, Associate Editor

space/aeronautics 33/1 (Jan. '60)

p. 68

Special Report:
Undersea Weapon Systems

Astia code: 2-9
Your code:

The undersea environment

Review of some basic characteristics of the undersea environment. Major topics include the ocean floor, sediments, currents, and properties and phenomena of the sea water medium. A pullout chart of major oceanographic features of North Atlantic.

by Bernard Kovit, Associate Electronics Editor

space/aeronautics 33/1 (Jan. '60)

p. 51

Special Report:
Undersea Weapon Systems

Astia code: 12-1, 31-4, -5
Your code:

State of the art: hydrodynamics, structures, materials

Latest advances, and trends are discussed. Influence of aviation methods on advanced anti-submarine designs is noted. Hydrofoils, ultra-deep submarine structure, and supercavitating propellers are among the areas covered.

by Irwin Stambler, Associate Editor

space/aeronautics 33/1 (Jan. '60)

p. 72

Special Report:
Undersea Weapon Systems

Astia code: 5-2; 6-1, -3, -6, -8
Your code:

State of the art: detection and communications

Outline of major problems in detection and communications. Non-acoustic and acoustic detectors are described. Acoustic and electromagnetic methods of communications with submarines are treated. Attenuation frequency curves for the radio-to-gamma-ray electromagnetic spectrum are included.

by James Holahan, Electronics Editor

space/aeronautics 33/1 (Jan. '60)

p. 58

Special Report:
Undersea Weapon Systems

Astia code: 12-1
Your code:

Cavitation problems loom large in underwater missile design

Theory of formation of cavities around underwater bodies is discussed. Results of new research on the inception of cavities around bodies under conditions of rapidly accelerating forward motion are described.

by Robert H. Oversmith, Convair

space/aeronautics 33/1 (Jan. '60)

p. 77

To make filing easier, each abstract is coded according to the Astia Distribution Guide. Copies of this guide are available from Armed Services Technical Information Agency, Arlington Hall Sta., Arlington 12, Va. There is also room on the abstracts for you to insert your own key if you use a special coding system.

Special Report:
Undersea Weapon Systems

Astia code: 30-4
Your code:

How to build a hydro-acoustic test tank

Describes choice of type and design of tank, structure, dimensions, capacity, and acoustic insulation. Noise and pulse test systems used in the facility are reviewed.

by Richard L. Beam, Hazeltine

space aeronautics 33 3 (Jan. '60)

p. 89

Aerospace Engineering
Materials Structures Production
Engineering

Astia code: 17-4, -5
Your code:

Which metals for high temperature structures?

Review of refractory metals and their alloys, super-alloys, and high strength steels, and their possible applications in high performance structural design. Data on the relationships of physical and mechanical properties and on producibility are given.

by V. D. Barth & H. R. Ogden, Battelle Memorial Institute

space aeronautics 33 1 (Jan. '60)

p. 129

Aerospace Engineering
Materials, Production Engineering,
Structures

Astia code: 14-8
Your code:

New design approaches needed for silica-phenolic ablation materials

Some design consideration, in working with Astrolite silica-phenolic ablation material. Fiber orientation, density and resin content must be carefully considered to take full advantage of inherent ablation material properties.

by C. S. Brown, Thompson Fiber Glass

space aeronautics 33 1 (Jan. '60)

p. 110

Aerospace Electronics

Astia code: 8-2
Your code:

Ferrite phase shifter paves way for inertialess scanning radar-II

Review, in the light of experimental evidence, of design methods for applying ferrite phase shifters to an X-band radar. Brief treatment of phase scanning in conjunction with frequency scanning; emphasis of discussion is on phase shift scanning in two planes (azimuth and elevation).

by F. E. Goodwin & T. A. Nussmeier, Hughes Aircraft

space aeronautics 33 1 (Jan. '60)

p. 150

Aerospace Engineering
Structures, Aerodynamics, Materials,
Production Engineering

Astia code: 1-3
Your code:

Designing the structure of a Mach 3 transport

Review of parameters of surface, wing, and fuselage structure design of a trisonic transport, covering density effects, compression allowables, rigidity, etc. Sandwich and stiffened-skin structures are compared in performance and cost.

by M. G. Childers, Lockheed Aircraft

space aeronautics 33 1 (Jan. '60)

p. 114

Aerospace Electronics

Astia code: 19-1
Your code:

"Transparent black" absorbs light noise in astro-trackers

Description of Luxorb chemical coating, which, applied to optical lenses and prisms, attenuates incident light, on the basis of "refractive-index matching." Characteristics and capabilities of this coating and its application are discussed.

by John Monroe & T. E. Rodgers, Northrop

space aeronautics 33 1 (Jan. '60)

p. 39

Aerospace Engineering
Production Engineering

Astia code: 26-1
Your code:

How to braze in a vacuum

Description of methods and apparatus for small-job-lot brazing operations. Pumping devices, sealing methods, and vacuum measurement are discussed.

by F. D. Seaman & E. M. Lundgren, Westinghouse Electric

space aeronautics 33 1 (Jan. '60)

p. 121

Aerospace Electronics

Astia code: 8-2
Your code:

Twenty-sec synchro resolver supports Polaris platform (Design Digest)

Design details of synchro resolver that achieves the high accuracy needed for precise one-speed data transmission systems. Photographic closeups and simplified electric schematics are presented.

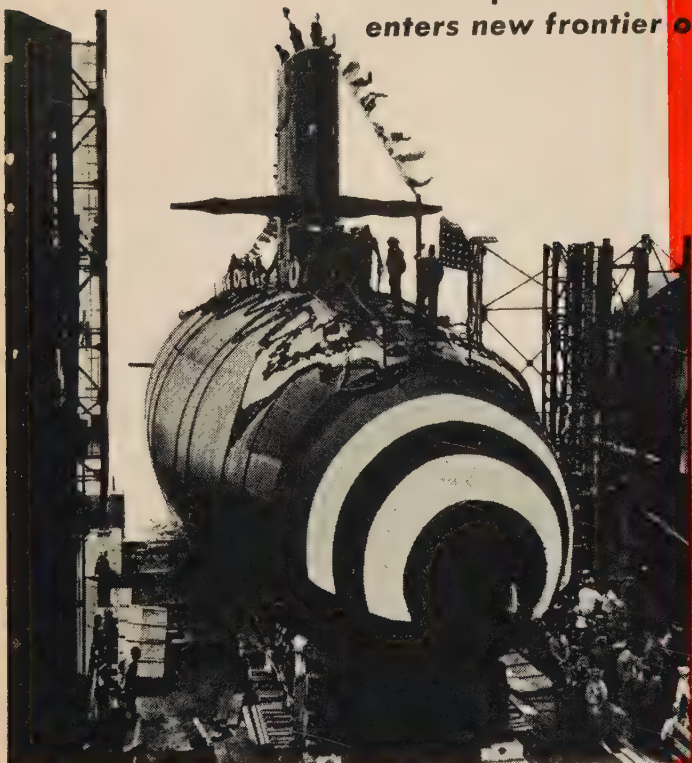
by Bernard Kovit, Associate Electronics Editor

space aeronautics 33 1 (Jan. '60)

p. 159

more on page 13

Pioneer producer of high pressure space/aeronautics valves
enters new frontier of atomic sub control systems operation



SKIPJACK—The first of a new class of nuclear submarines produced by General Dynamics Corporation's Electric Boat Division

Using the know-how of high pressure valve design developed over the past years for the missile and aircraft industries, Marotta is meeting the challenge of the new atomic submarine for reliable high pressure control valves and regulators.

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by Dean Anderson, North American Aviation

space/aeronautics 33/1 (Jan. '60)

p. 167

Aerospace Electronics

Astia code: 8-2
Your code:**Finding the characteristics of artificial atmospheres**

Two nomographs for (1) computations of temperatures, pressures, and gas densities, providing two of these parameters are known and the gas approximates the perfect gas law, and for graphical solution of the standard gas law equation.

space/aeronautics 33/1 (Jan. '60)

p. 163

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IT'S TRUE we're still having considerable trouble merely hitting the moon, but that doesn't mean we can let off planning for the time when we'll have progressed to actually landing on the moon. The design problems that are involved here—for both hard and soft impacts—will be covered in detail by Contributing Editor Kurt Stehling.

IN ONE of his design analyses, associate editor Irwin Stambler will take up one of our most important developmental air-launched ballistic missiles.

FLIGHT CONTROLS over the last few years have been expanding steadily in terms of technical complexity and variety. In a comprehensive roundup article, SPACE/AERONAUTICS will review the state of the art in this field, covering the entire spectrum from jetliners to manned spacecraft.

coming soon

THE PROBLEM of secondary power continues to be critical for all advanced aerospace vehicles—some of them actually are limited by their secondary-power sources. To bring you up to date on the latest developments in this area, SPACE/AERONAUTICS will publish a detailed comparative report on the many schemes that have been put forward so far.

ANOTHER special report is coming up. We can't afford to tip our hand yet, but this much is safe to say—it will cover one of the most important new design areas in aerospace electronics.



We need an information breakthrough

DO TECHNICAL magazines carry "too much information"? Some people think so. We find them not only thickly populating certain government agencies and top administrative posts, but there are a few in industry as well.

We well remember the Defense Department official who held that while the data we planned for a special report was not classified, it somehow became "classified" when put together all in one issue of *SPACE/AERONAUTICS*. This was our Missile Systems Engineering special report of November 1957.

It has since come to pass, as the DOD just admitted publicly, that a missile gap will exist from 1961 through 1962—perhaps into 1963—between the Soviets and the U.S.

Now, much as we may have a high regard for the sterling qualities of our special reports, we nevertheless cannot bring ourselves to believe *SPACE/AERONAUTICS'* editors had anything to do with contributing to Soviet supremacy in ballistic missiles. No technical person seriously could hold that belief. The missile gap, in fact, already existed at the time of our report, for the Soviets had fired their first ICBM over 5000 miles several months earlier. Our Atlas didn't equal that feat until the following year—through no fault of Convair's, we might add.

This prejudice against spreading information exists in high quarters, and is at the root of one reason for our lagging behind the Soviets in both missile and space programs. "Need to know" rules, one symptom of this prejudice, are made by people who apparently do not fully realize that the exchange of information is the lifeblood of any technical society. "Cross-fertilization" is as necessary to the growth of our technologies as it is in nature.

There are three reasons behind restrictions on the spreading of information: political, security, and proprietary. The first is indefensible. It has no place in our political philosophy. The other two contain gray areas in which personal judgment is a factor. The attitude in cases involving security is to release as little data as possible. Whatever can be hidden, bury it. When it is dragged, kicking and screaming, from its hiding place, give it a tranquilizer.

The tendency of this policy is to concentrate on keeping as much as possible under wraps to the point where, in extreme cases, the Reds have all pertinent data while U.S. engineers still are denied it. A classic case of this sort was the Republic F-84. Years after an operational aircraft had landed by mistake in Czechoslovakia, and the Reds had examined it piece by piece

and then kindly returned the remains to U.S. authorities, the F-84 was still banned from publication.

Security regulations need desperately to be overhauled. Not only do the regulations need to be overhauled, the basic philosophy behind them needs revision. There is a need for security. But a point is reached where it is more valuable to disseminate the data to our own engineers across the board than it is to hide it from the Soviets. We should like to suggest that our security officials get together with such technical people as Hall Hibbard, A. E. Raymond, George Schairer, R. C. Sebold, and others, to determine just when the point is reached where the values of withholding data from the enemy are outweighed by the requirements of our engineers to have access to it freely.

Big factor in wasted efforts

The lack of communication and technical data dissemination between the military services, between companies, and between engineers and scientists working on government projects was pointed out by *SPACE/AERONAUTICS'* Editor last month (*"Why We Lag in Missile and Space Programs"*, Dec. '59, p. 40). To keep key pieces of technical data under wraps so that engineers and researchers not on specific projects never know of them can be ten times more costly in delays, wasted efforts, manpower, and money than revealing these data to an enemy. At least \$20 million has been spent on the throttling rocket engine, for instance, and we still don't have a good throttling rocket engine. How much interchange of information has there been between Curtiss-Wright, Reaction Motors, Rocketdyne, Bell, and Aerojet-General on their work?

Most cases of company "proprietary" information lid-clamping are justified, although, again, where human judgment is concerned some decisions are debatable. There are a few close-mouthed company officials who regard any information on company technical activities as proprietary.

The point to keep in mind is that no nation can win a technological race by feeding on crumbs from another. Nor can it win by stifling the flow of data among its own researchers and engineers.

William L. Maass
Publisher

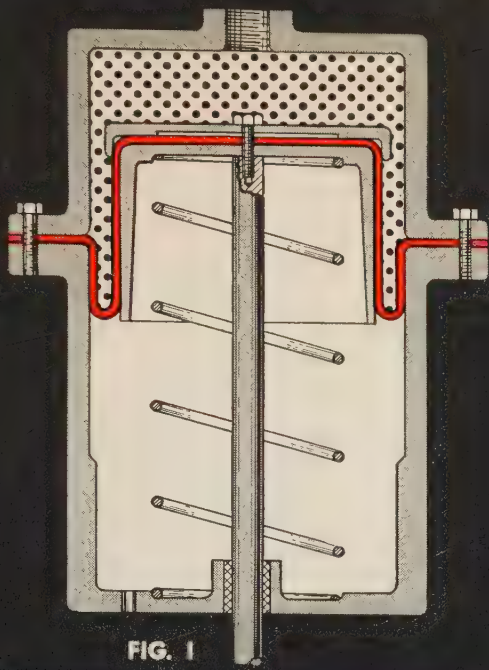


FIG. I

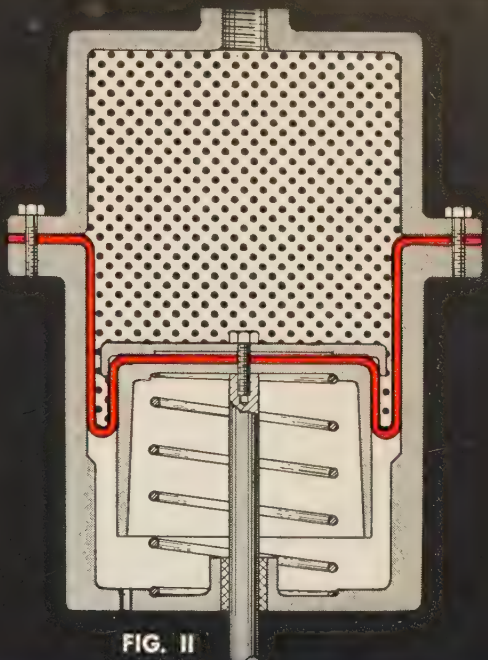


FIG. II

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Fig. I shows how Bellofram Rolling Diaphragm conforms to the piston. Fig. II shows how, as the piston descends under pressure, the Bellofram Rolling Diaphragm *rolls* off the piston's sidewall and onto the cylinder's sidewall in a smooth, continuous, frictionless movement.

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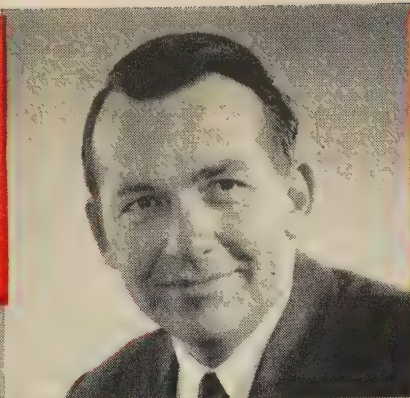
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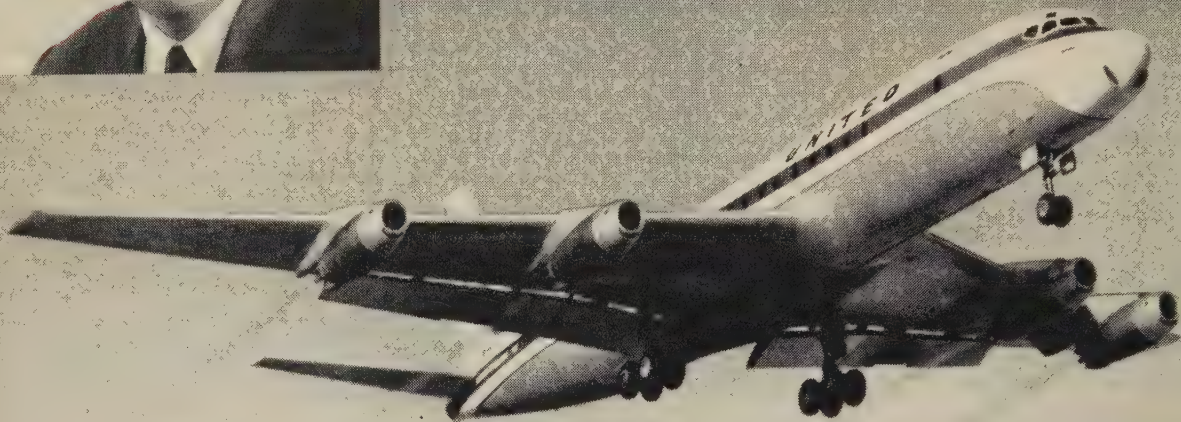
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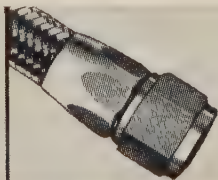
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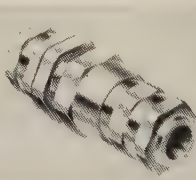
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editorial

New threats, new requirements, new frontiers

WHILE THE SOVIETS alternately fill our ears with soothing sounds of “peace” and the menacing rattle of their rocketry, they quietly ready a new threat. This one comes from the sea.

Speaking at the NATO parliamentary conference, NATO Atlantic commander, Admiral Jerauld Wright said:

“We have conclusive evidence that the Soviets are constructing ballistic missile submarines and will be able to launch via the seas a significant threat against NATO within one year, with a serious threat developing by ’63.

“We have conclusive evidence that they are showing an increased interest in the east coast of North America, a key area and an industrial complex of the first importance, not only to America, but to our NATO alliance.

“In view of this, our sea defenses take on added significance.”

A GAINST THIS BACKDROP we shaped our Undersea Weapon Systems report (beginning on page 39). The threat warned of by Admiral Wright is so grave that it calls for a more determined effort in the UWS field by the aerospace industry. Many firms already are involved. But up to now, generally speaking, industry has “backed” into UWS programs. Air and space alone have been regarded as its “true” domains.

But aerospace technologies are applied to problems of the sea frontier. We desperately need breakthroughs in UWS detection and communications. Merely to find a submarine in the vast oceans is beyond the reach of today’s knowhow. Communications to and from undersea conditions are far short of needs.

THE ANSWERS must come from basic research. Knowing this, the Navy had a study made of basic research needed to support all its technological requirements, including UWS. This study was headed by Dr. Guy Suits, General Electric’s director of research, and carried out for the Naval Research Advisory Committee by Arthur D. Little, Inc., Cambridge, Mass.

In 1947 the Navy was devoting 10 per cent of its R&D spending to basic research. This compared favorably with leading industrial corporations. Last year, however, basic research money accounted only for 6-8 per cent of the Navy’s R&D funds. Meanwhile, ten of the most successful corporations in five technically based industries devoted an average of 16 per cent to basic research. In dollars, top corporations tripled total R&D and upped basic research by 350 per cent. At the same time, the Navy doubled R&D, but increased the basic research part by only 50 per cent.

This reveals, in part, why the Navy must look to industry for help. Shortsighted Administration officials will not grant the importance of basic research to the country. They will therefore allow only a pittance for it in the budget.

The “new” sea frontier offers both a challenge and an opportunity to aerospace technologies.

Randolph Hawthorne, Editor

THE SAGINAW^{b/b} SCREW SAVED THE DAY WHEN...

A Garland Telescopic Crane Had to Lift an Atlas Missile!

"We were *really* up against it when we had to put up a 3-ton Atlas Missile for display at the World Congress of Flight in Las Vegas. Our telescopic crane was unable to "boom up" that much weight, with the high-friction threaded shaft we'd been using.

Thanks to the competent assistance of your factory representative, and prompt delivery of the proper Saginaw Ball Bearing Screw, we licked the problem over a week-end. The Saginaw Screw's 90%-plus efficiency *actually tripled* our crane's boom-raising capability! It even brought us a *second* order from the Air Force. We're not only going to add Saginaw Screws to every new Garland crane, but install them in every one of the 1200 Garland cranes already in use!" says Carl Frye, Sales Manager, Garland Crane Co., Long Beach, California.

Perhaps the Saginaw b/b Screw can give *your* products that greater Sales Appeal you're looking for. Want details? Just write or phone Saginaw Steering Gear Division, General Motors Corporation, Saginaw, Michigan—*world's largest producers of b/b screws and splines.*

The Saginaw b/b Screw converts rotary motion into linear motion with over 90% efficiency. Saves power, space, weight, gives day-in, day-out dependability.

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Have been built as small as $\frac{3}{16}$ in. B.C.D. and $1\frac{1}{2}$ in. long, as large as 6 in. B.C.D. and 40 ft. long. Larger sizes can be built to your order.

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washington briefing

by **A. N. Wecksler**, Washington Bureau Chief

How Congress decides DOD's and NASA's budgets

ON DECISIONS involving space exploration, members of Congress during the current session will be strongly influenced by what scientists in the field tell them.

The Government agencies concerned with space will continue to get the widest power of decision over what programs to pursue and how to proceed. The only limitation will be the amount of money that will be appropriated.

In military space and aeronautics, the trend is for greater control by Congress on not only the level of military spending, but also on what weapons will be bought and how they will be purchased.

This year studies will be made of military procurement policies and procedures, with the aim of tightening Congressional control over what and how the military buys—especially in the field of missiles, aircraft, and ships.

As for the overall military appropriation outlook, the White House decision to hold fiscal 1961 spending to the same levels as fiscal 1960 will stick, as far as Congress is concerned.

There have been signs of revolt from Senators who have favored higher levels of military spending. Senator Stuart Symington (D., Mo.) in the past has called for higher levels of military spending, and will do so again during the current session of Congress.

Senator Lyndon Johnson (D., Texas), majority leader of the

Senate, favors a higher level of military spending, but was not able to get Congress to go along with him last year, and the chances are even slimmer now.

Senator Henry M. Jackson (D., Wash.) has already announced that he favors adding some \$5 billion to the military budget.

Overriding this position is the stern injunction by President Eisenhower to hold the line on the military budget. From a practical political position, unless some direct military threat develops, it is virtually certain that Congress will not exceed the President's recommendations on a military budget in an election year.

In the space field, the approach in Congress is largely to determine whether anything can be done to accelerate our progress. There is little question among Congressmen about the willingness of the electorate to back up our competition with the Soviets.

Both the Senate Space Committee and the House Committee on Science and Astronautics will be reviewing NASA achievements and planning to see whether they are moving fast enough. The thinking will be very much the same as it was when NASA was established. Congress is willing to buy as much time as it can to catch up with the Russians, and the members of Congress have very little patience with a cautious approach.

At the same time, while members of Congress may feel somewhat familiar with military programs and money requirements, there are few Congressmen who have any real knowledge or even background in science and technology.

What Congress will be looking at is the Government organization that has been set up. This is a field of which they have some understanding.

The House committee will be holding hearings all this month into such questions as:

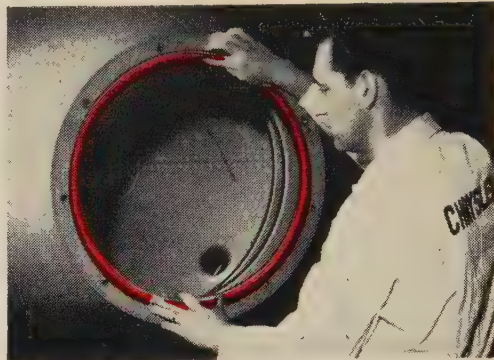
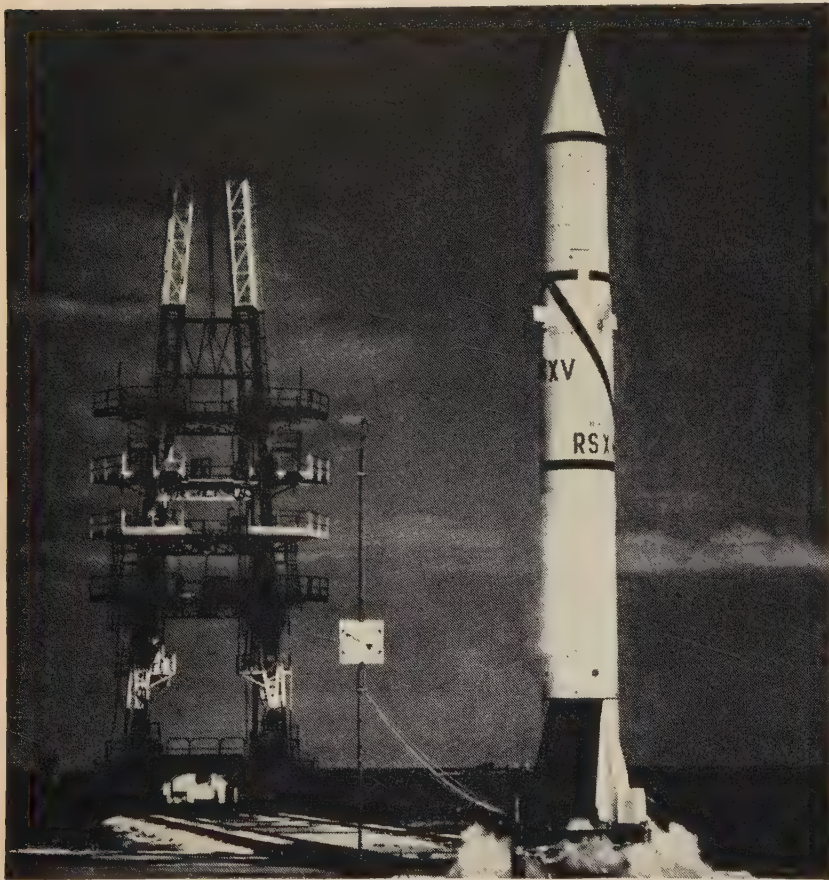
- Does the U.S. have an overall national space program?
- Is sufficient money being allotted to both the military and civilian space programs?
- To what extent do the civilian and military agencies doing space work correlate their efforts?
- Does the Administration plan to subordinate either the military or civilian space efforts?

• What will the specific missions of the individual services be in the space effort?

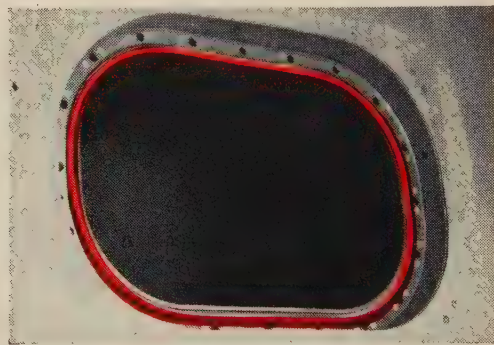
In addition, the Congressional committee will be looking into the NASA-Army Ballistic Missile Agency relationship and the progress of the Saturn booster program.

But essentially what the members of Congress would like to see is equality in the space race with the Russians at the least—and superiority as soon as possible.

Semper Flexibilis



Sealing the nose cone on the Army Redstone is an extrusion of Silastic. Silastic maintains a positive seal despite long periods of storage under load and adverse operating temperatures.



A similar application for Silastic, this time on the Army-developed Jupiter IRBM, another Chrysler-produced missile, is the seal on the angle-of-attack transducer compartment. Silastic was specified because it resists high temperatures encountered in re-entry.

SILASTIC
SILICONE RUBBER

seals missile sections;
withstands -130 to 500 F

Till the moment when it separates during trajectory, the Army Redstone's warhead sits on a flexible seal of Silastic®, the Dow Corning silicone rubber. In fact, all sections of the missile are joined in this manner, to maintain pressure. Chrysler Missile Division engineers also utilize Silastic for many other applications, including ducting, wire bundle clamps and access door seals.

Silastic does these jobs so well because it offers reliability at all times . . . remains flexible even after long storage, at high skin temperatures, under compressive loads, in presence of ozone, cold, moisture. It is unaffected by weathering: 9 years exposure at a South Florida test station has failed to damage sample Silastic parts.

When your "bird is in the hole" and exposed to an environment of weathering, ozone, storage effects and a wide temperature range, you want reliability of rubber parts. Your rubber company supplier can engineer a part made of Silastic to suit your particular requirements. For more information, write Dept. 0701.



Chrysler Missile Standard Bundle clamps on both Redstone and Jupiter missiles are fabricated of Silastic. Electrical properties of this material are excellent.

If you consider *all* the
properties of a silicone rubber, you'll
specify Silastic.



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SPACE/AERONAUTICS



industry viewpoint

by **Robert M. Loebelson**, Associate Editor

A single agency for ASW!

ACTIONS will speak louder than words!" That well-worn phrase is being used by one of the industry's most knowledgeable individuals to describe his feelings about military spending on anti-submarine warfare (ASW).

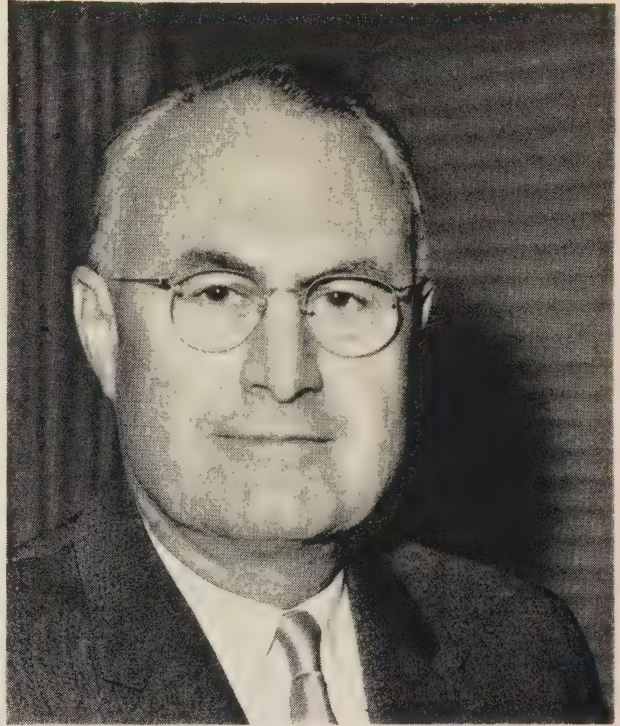
L. B. Richardson, senior vice president-engineering at General Dynamics and a retired Navy rear admiral, is in a good position to know many of the Navy's anti-subwarfare problems and help to find solutions for them. As the top engineering official of a firm that is involved with killer submarines (Electric Boat's Tullibee), electronics and electro-acoustics (Stromberg Carlson's sonar and sonobuoy receivers), ASW aircraft (Canadair's Argus), ship-based missiles (Convair-Pomona's Terrier and Tartar), and ASW operations and systems analysis (at Convair-San Diego), Richardson is fully aware of the actual state of the Navy's undersea warfare programs.

He puts his complaint this way: "There is no one place in the Navy to go to find out about anti-submarine warfare requirements. ASW seems to be everyone's business, and there is no single agency responsible for it.

"The Navy has put out many thousands of words about the Russian submarine threat and what we are doing to overcome it. But even Navy accountants give differing figures on appropriations going for ASW. One thing is certain. If the Russian submarine threat is as dangerous as the Navy says, we are not spending enough to counter it."

Richardson says the Navy's past expenditures on R&D have been fruitful in the ASW area, but insists there simply has not been enough money. "Industry has plenty of good ideas on how to overcome the sub threat, and many of them should be investigated with R&D money. Among them," he declares, "are sonar concepts to help detect submarines and ideas on classifying subs operating at great depths."

The General Dynamics official believes both industry and the Navy would benefit if ASW responsibilities and authority were concentrated in a special-

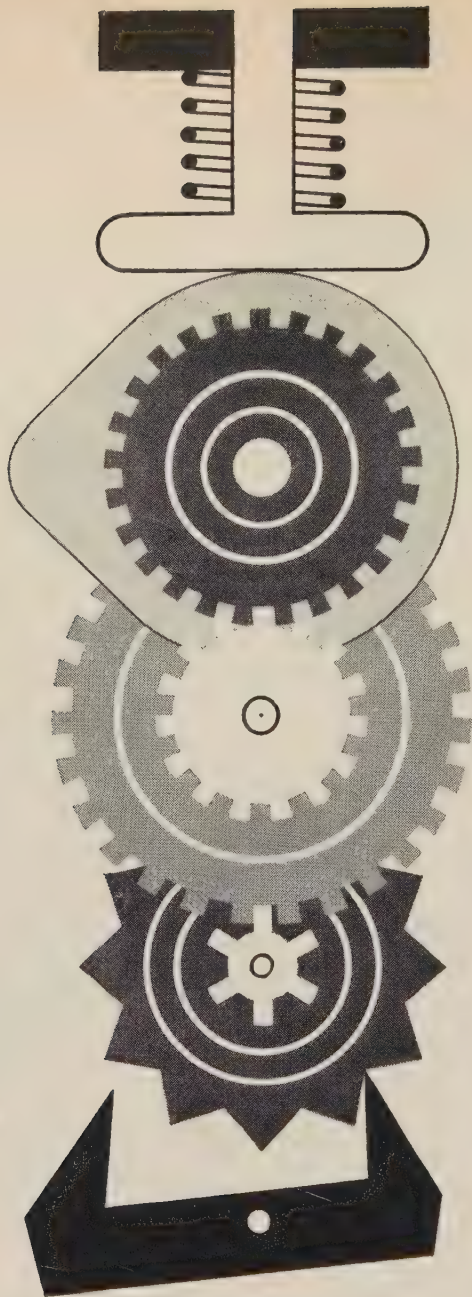


L. B. RICHARDSON, senior vice president-engineering, General Dynamics Corp.

projects office instead of being scattered throughout the Navy. "The task-force approach used by Admiral Raborn's office to develop the Polaris missile and its launching submarines proves the advantages of such a setup," Richardson says.

He points out that opponents of the special-projects approach for ASW contend that not every military problem can be singled out for special handling. "The Navy tries to follow its usual procedures with its normal organization. But the ASW program is supposed to be important enough to warrant special treatment."

Richardson insists that once the Navy makes up its mind that the special-projects approach to ASW is desirable, it should also define what weapon systems ASW should include and fund all of its ASW work through that office. "We know, for example, that destroyers and aircraft carriers are used in anti-submarine operations. But I can't see ships of that type funded by a special-projects office working on ASW," Richardson declares.



Escapement mechanisms... by Bulova

Bulova engineering extends from requirement to mass production



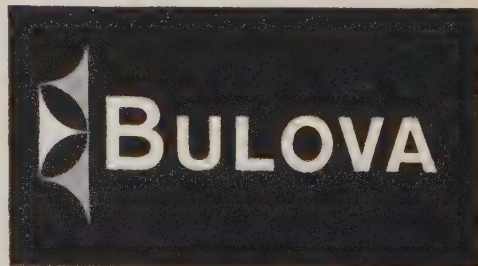
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technical management intelligence

Next year's defense budget bound to make Congress unhappy

CONGRESS SHOWS SIGNS that it will be very unhappy with the Defense Department when the President's budget for fiscal '61 is submitted later this month. DOD officials who testify will be given a hard time by members of the House and Senate Military Appropriations committees.

Present indications, however, are that there will be no major effort to increase appropriations beyond the \$41 billion to be requested for DOD and the services.

THE RECENT RESIGNATIONS of Defense Secretary Neil H. McElroy and long-time Pentagon comptroller Wilfred J. McNeil mean that the two "chiefs" who worked up the '61 budget will not be there to defend it when hearings are begun by the House Subcommittee early in February. McElroy, who returned to Procter & Gamble after a 26-month Pentagon stint, has been succeeded by Deputy Secretary Thomas Gates, a former Secretary of the Navy who was persuaded to take the No. 2 DOD job after Donald A. Quarles died last May.

Few in Congress will be able to find a legitimate excuse for either refusing to confirm Gates or raking him over the proverbial coals during the budget testimony. Among other things, he is an experienced Pentagon hand who was in on the budget formulations and can therefore defend the decisions reflected in the budget message with some authority.

New DOD comptroller will be going to bat for a program he didn't draw up

BY CONTRAST, the new DOD comptroller, Franklin Lincoln, is taking over his post at an awkward time, even though McNeil will be on hand as a "consultant" for much of the budget testimony. Lincoln, held no Pentagon budget post under McNeil. He will therefore be testifying on a budget that he did not draft and defending weapon systems with which he cannot possibly be familiar.

THE MCELROY RESIGNATION, tipped months in advance by the Cincinnati soap executive himself, is causing lawmakers to reanalyze the stringent rules under which industrialists serve in the Pentagon. The Senators and Congressmen, look-

ing at the short tenures of past Defense secretaries and deputy secretaries and their counterparts in the Army, Navy, and Air Force, are beginning to realize that the relatively low pay at the Pentagon cannot possibly attract top decision-makers from industry.

Past Congressional insistence that nominees for high Pentagon positions give up their stock and many other rights in the companies they leave may well be on the way out. The lawmakers will take a new look at the possibilities not only of liberalizing the stock divestiture requirements but also of increasing the high level Pentagon pay scale and/or expanding the without-compensation (WOC) approach.

Some DOD officials are serving as WOCs, with their civil employers continuing their pay. Precedents for this situation go back even beyond the dollar-a-year men of World War II.

ALTHOUGH THE NUMBER of dollars for defense in the '61 budget is just about the same as for the current year, many programs the services consider vital to national defense are being eliminated. The traditional factors of inflation and high unit cost and complexity naturally account for much of this trend. But this year the so-called Camp David spirit, the possibility of nuclear disarmament, Eisenhower's desire to balance his last budget, and the fact that many programs are ready to emerge from the research stage and will start costing real money all combined to force cuts in essential programs.

Need for Mach 3 bomber is generally admitted, but B-70 is cut to the bone anyhow

NORTH AMERICAN's B-70 bomber and its GE J93 engine are the foremost examples. No responsible USAF official seriously questions the advisability of a manned bomber to succeed the Boeing B-52 and Convair B-58. Even the civilians and generals who tend to put greater trust in ballistic missiles for deterrence and strategic warfare admit the need for a Mach 3 bomber.

But the high cost of the B-70 forced DOD and USAF to all but wipe out the plane completely. In an inevitable sequel to the Air Force's cancellation of the Mach 3 F-108 interceptor last September, the military planners had no choice but to cut the B-70 production program back to one prototype.

more on next page



technical management intelligence

ASIDE FROM the military implications of having to make do with the subsonic B-52 and Mach 2 B-58 for several years longer than planned, USAF's action can only result in a delay of at least 3-4 years in the development of a commercial 2000-mph aircraft. Airline executives had hoped that military work on the B-70-J93 combination would make it possible to have a Mach 3 airliner in service between '72 and '75.

USAF's action may defer the civil trisonic jet until perhaps '80. (However, the basic reasons behind the '72-'75 target date were economic, not technical).

Either Atlas or Titan may still be abandoned

ALTHOUGH DOD OFFICIALS testified earlier this year that the point of no return had been passed for canceling one of our two liquid-propellant ICBMs, the subject is again up for debate. If USAF planners can figure out a way to make substantial savings by merging the Convair Atlas and Martin Titan programs, one of the two may still be abandoned, despite the hundreds of millions spent on each missile to date.

Another factor that would help resolve USAF's would be some unexpected progress on the solid Boeing Minuteman ICBM. AF is hoping to get the Minuteman in service by '63 at a price "in the hole" of \$1-1.5 million per missile. Atlases and Titans cost upwards of \$2 million for the "birds" alone. Bases and ground support equipment run the unit price of the two liquid ICBMs (based on present production schedules) up to more than \$10 million each.

Although the Minuteman will carry a smaller nuclear warhead than either Titan or Atlas, it will still be an instantly available deterrent or strategic weapon. If its '63 delivery date is moved up, two liquid propellant missiles would be an obvious consequence.

IN THE ANTI-MISSILE missile area, the questions are still whether Nike-Zeus, the only "auntie" under active development, will be effective against Soviet ICBMs and whether we are willing to pay out the \$12-15 billion that 40 or so Zeus sites would cost. Many responsible DOD officials honestly believe that neither Zeus nor any other "auntie" can stop a ballistic missile in time to save SAC bases or U.S. cities. However, they say so openly because of the possible psychological effect on the public.

THE ATOMIC AIRCRAFT PROGRAM, while not as shaky as other military projects, is still in for some rough going. "Aircraft Nuclear Propulsion" (ANP) was hit by a 15 per cent cut at GE-Evendale last October, but still seems solidly in the budget picture for '61. While funding will remain at or near the present research level there may be a shake-out of contractors.

AEC COMMISSIONER John F. Floberg would like to see both the GE direct-cycle and the P&WA indirect-cycle engines continued as R&D projects and flown in test beds before a choice is made between them. But AEC Chairman John McCone is hinting the choice may have to be made before that. Present prospects are that, in that case, the P&WA design will survive.

Meanwhile both two engines and the Convair and Lockheed airframes to house them are all being funded. The problem for AEC and USAF programers is how much of their approximately \$150 million to allocate for each participant in ANP.

NAVY IS ALSO HAMPERED by fund shortages for next year. The nuclear-powered carrier authorized by Congress with '60 money will be powered conventionally to save money. Some of the Navy's '61 programs are being scuttled, among them the P&WA, a 30,000-pound-thrust-class turbojet.

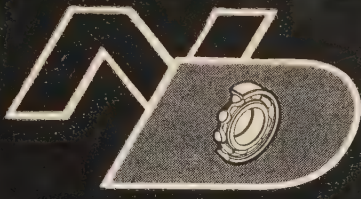
It's official now: Soviets are steadily gaining on us in space race

U.S. ORGANIZATIONS involved in the space program are now admitting that we are falling ever farther behind the Russians. At the time of Sputnik I in October '57, it was officially estimated we were two years behind the Reds. Since then, the gap has been steadily widening. Failure of the U.S. attempt to orbit an Atlas-Able around the moon means another big setback, because no back-up vehicles are available for "civil" space shots.

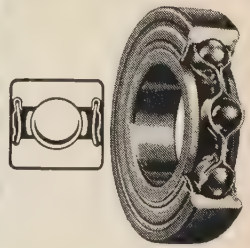
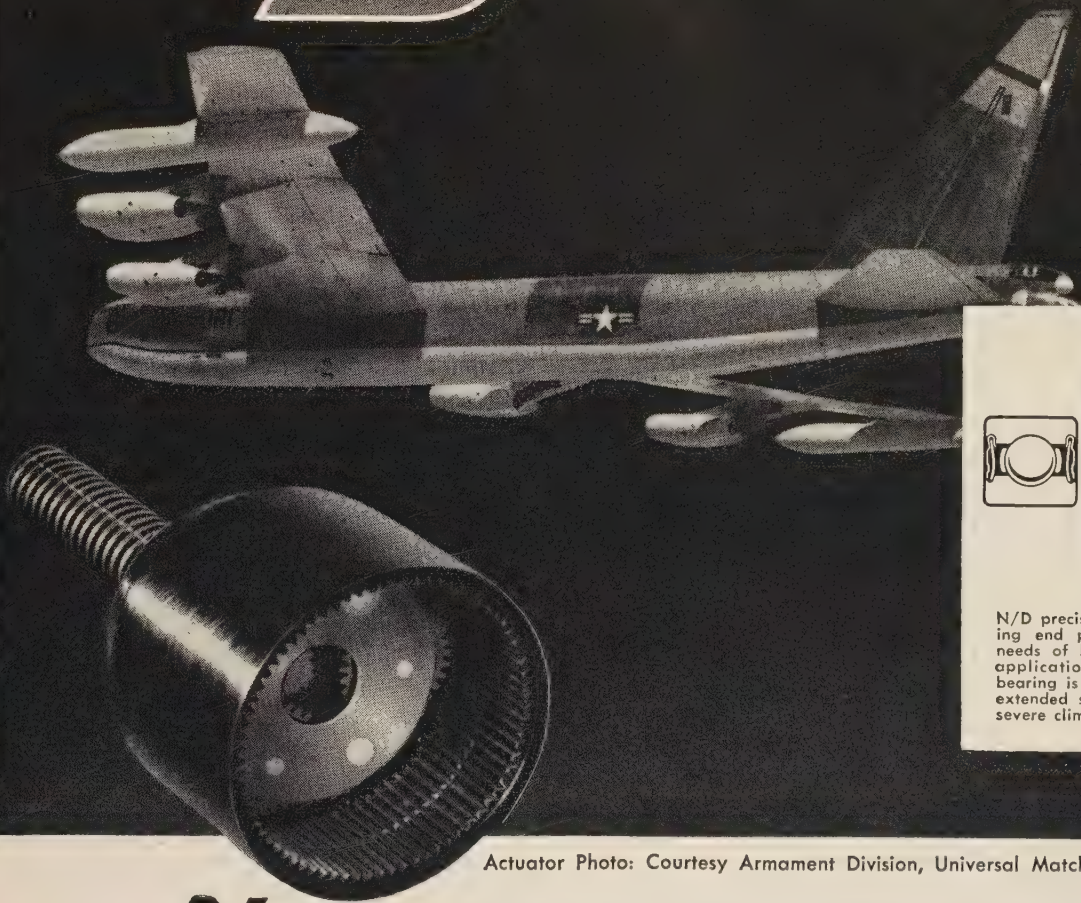
Some estimates now even place us a decade in back of the Russians. Yet there is still no concerted drive to try to narrow their lead.

NASA'S BUDGET, which was set at \$500 million for the current year and had been programmed for close to \$1 billion for fiscal '61, will

more on page 26



CASE HISTORIES



N/D precision ball bearing end play surpasses needs of linear actuator application. Moreover, bearing is lubricated for extended service against severe climatic condition.

Actuator Photo: Courtesy Armament Division, Universal Match Corp., St. Louis, Mo.



Production Ball Bearings Give **Low Cost Answer To B-52 Actuator Problem!**

CUSTOMER PROBLEM:

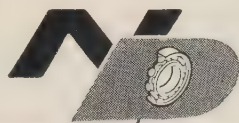
Manufacturer experienced rejects in B-52 aileron trim tab actuator inspections because over-all linear motion could not be held to specified limits.

SOLUTION:

To hold linear actuator end play to proper tolerance, the thrust-supporting ball bearing end play had to be held to a maximum .003". N/D Sales Engineer, working with the manufacturer, recommended New Departure *low cost* single row production ball bearings with standard N/D close internal tolerances. Extensive testing proved that these N/D *production* ball bearings surpassed

specifications, assuring end play .001" less than allowed limits. Most important, these high precision N/D ball bearings supplied definite cost advantages over the previous bearings used which required costly hand selection. All this, thanks to New Departure's advanced inspection techniques.

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show up at \$700-\$800 million in the budget message to be submitted this month. Military space programs are not faring much better—they are suffering from the same fiscal anemia as other military programs.

USAF's Dyna-Soar is a case in point. After a long period of study and awards of Phase I contracts to Martin and Boeing (which had each lined up associate contractors before submitting bids), AF picked both firms for the program, keeping the prime contractor role for itself.

Martin will manufacture the booster, which will be a Titan ICBM modified to a degree that hasn't been determined yet. Boeing will manufacture the orbital vehicle and assembly and test the booster-vehicle combination. All major subsystems and components will be picked competitively, AF has decided, and without regard to working arrangements made during the development phase.

Dyna-Soar program includes no plans for early hardware

DESPITE USAF'S VIEW that Dyna-Soar will be the prototype for a true manned space bomber, the present program does not involve any immediate plans for hardware. The first step will be the design and testing of a glider that will bring a man back from Mach 5 speeds to a normal landing. Next will come unmanned and manned glider flights from Cape Canaveral, Fla., and finally powered Dyna-Soar flights.

This program obviously leaves a bomber that will orbit several times before re-entering the atmosphere far off in the future.

ONLY TWO OR THREE YEARS AGO, White House, DOD and State Department officials were pointing out that this country could not hope to match Russia weapon for weapon and man for man, and that we were therefore relying on being "qualitatively superior." There is no doubt that we are still numerically inferior and plan to stay that way. And after the recent Russian achievements in aircraft, missile, and spacecraft design, we are not even "qualitatively superior" any longer. Interestingly enough, the phrase seems to have disappeared from the Pentagon-White House-State Dept. vocabulary.

CONTINUING our space program "at the present level is largely a waste of money," Dr. Eberhardt Rechtin, of Jet Propulsion Lab, declared

in a recent speech. "At the moment, we are paying for the privilege of being the perfect straight man for the Russians. As Dr. Glennan has stated, 'we cannot run second very long and still talk of leadership.'"

"If we decide to take the space race seriously," said Rechtin, "it will certainly cost us more money than we are presently spending. We should probably spend the amount that Dr. Killian initially estimated—about 1.5 billions per year, or about something less than five per cent of our defense budget.

"We are going to need clearly defined goals, . . . facilities, and priorities," Rechtin continued. "We need a very hard-boiled look at the past performance of groups in the U.S. and a willingness to let the finally chosen professionals run their own race."

ENROLLMENT in freshman classes of U.S. engineering schools in '58 was down about 8000 from '57, NASA Administrator T. Keith Glennan revealed. The Russians, he stated, graduated 94,000 in '58 and 106,000 in '59. They are training two scientists and three engineers to every one of ours in all aero-space fields.

Bulk of U.S. spacecraft effort to be handled by Von Braun team at Redstone

GLENNAN ALSO STATED that the bulk of U.S. work on space vehicles including carriers to take probes and satellites into outer space, will be handled by von Braun's group in Huntsville, Ala. This group, he stated, will be in charge of both the clustered Saturn and the 1,500,000-lb thrust single-chamber Rocketdyne engine.

SIKORSKY, which has produced more than 1200 S-58 helicopters, received \$23 million in Navy contracts to build the HSS-1N version for antisub warfare and the HUS-1 troop and cargo version for the Marines.

LOCKHEED will produce \$19.2 million worth of GV-1 aerial tankers and assault transports for the Marines. The plane is similar to USAF's C-130B turboprop.

USAF AND MARTIN got Congressional and DOD go-ahead for production of the tactical TM-76B Mace missile.

SCIENTISTS AND ENGINEERS: There are two sides to the STL coin...



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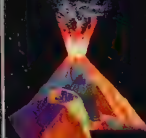
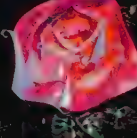
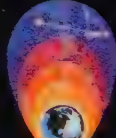
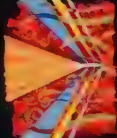
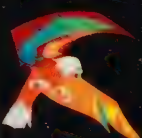
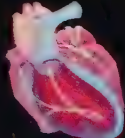
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Trend in ICBM design toward storability and firing readiness

BIGGER ICBMs do not seem to be in the cards. DOD now sees little point in making ICBMs like Atlas more powerful. After all, if Atlas goes any faster at apogee, it will orbit, and if it goes any faster on descent, it may disintegrate. Increases in payload capability also are no longer important, since the vehicle can already carry all the warhead it needs. Improvements from now on will come in storability, "shippability" (which probably will mean smaller designs), and firing readiness.

NAVY'S TRANSIT geodetic satellite schemes, now in the planning stage, are running into problems. The instrumentation and orientation difficulties are believed to be tremendous. Reportedly the whole project is up for review and may be canceled or thoroughly modified.

FIVE BRITISH Black Knight rocket research vehicles have been fired so far, and each has been completely successful. The latest reached an altitude of 450 miles and a maximum speed of Mach 10.

Black Knight's main use at present is in re-entry research. However, a combination of the Black Knight with the Blue Streak has been suggested as an all-British satellite carrier.

Lighter re-entry bodies through use of ablating Teflon

ABLATING TEFLON could provide appreciable weight savings in the design of re-entry bodies, according to du Pont researchers John C. Siegle and Paul H. Settlage. They claim that a Teflon coating less than 1/3 in. thick could provide protection for at least two minutes without heating the supporting metal underlay much beyond room temperature. Such a resin heat shield could be used in place of heavier designs based on ceramics or expensive metal alloys, according to du Pont.

TEFLON RESINS turn directly into a gas at extremely high temperatures. This means, the du Pont scientists point out, that the Teflon resin molecule separates link by link, while other polymers break up in chunks.

In the process of reversion to the gaseous raw material, a tremendous amount of heat is ab-

sorbed. The gas flow back along the heated surface also helps to dissipate heat. Tests show the Teflon cooling process can be quite accurately calculated.

PLASMARC TUNGSTEN coatings applied directly to graphite rocket nozzles stand up well, reports Linde, even when highly atomized propellants are used. They could be used under the present operating conditions of rocket nozzles—about 5500 deg F flame temperatures and around 500-1000 psi pressure.

TANTALUM UNDERCOATS could take slightly higher operating conditions, Linde says, because of the slightly higher melting point of the tantalum eutectic. New coatings with melting points of about 7000 deg F will be needed once flame temperatures go up to 6500 deg F, with pressures ranging from 1500 to 2000 psi.

Early warning from Triton sub over 110,000 miles range

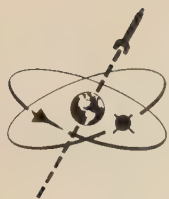
RECENTLY COMMISSIONED Triton submarine will have a cruising range of 110,000 miles and carry a crew of 173 men. She is fitted with high power radar and sonar gear for early warning detection of enemy planes, submarines, and surface vessels. Cost is put at \$100 million.

PROPORTIONAL BRAKING system developed by Hydro-Aire will be used on Convair's 600 jetliner. The anti-skid system automatically provides braking in proportion to wheel slip. A pulse emitter frequency from each wheel unit is sensed as wheel speed by an analog computer control box. As this speed changes, an electronic circuit—there is one for each wheel—follows the change, while a common memory circuit in the control box follows the speed of the fastest rolling wheel. Whenever a difference is sensed, current is sent to brake-pressure-metering valves to regulate the metered pressures. This current is non-linearly proportional to the speed difference.

54-H JEEP NEW AERIAL is being built for the Army by Piasecki. Its basic configuration is the same as that of the "jeep" model first flown by Piasecki in July '58. The new model will have two 425-hp Artouste II-4C gas turbines driving two metal rotors. These will be slightly larger and tilted to give higher speeds. Controls will be provided for a cockpit.

more on next page

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SUPER-SPEED RAMJET vehicle proposed by Boeing would probably use hydrogen as fuel and operate between Mach 6 and 16. The engine is designed so that supersonic combustion takes place across a stabilized, internal detonation wave. There would be no need therefore for decelerating the internal air below the speed of sound.

The detonation wave is stable because it has the same speeds as the internal air. Air speed is automatically increased or reduced to match variations in the detonation wave by varying the diameter of the air inlet channel and the fuel ratio. The heat of the initial detonation wave starts the combustion process.

A **VARIATION** of Boeing's combustion design was proposed in a thesis at Brooklyn Poly in '46. In this case, a combustion chamber was to be used in which an external air flow admitted at ram pressure could be balanced against an internal air flow admitted at the same or a lower pressure. By varying the angle at which the internal duct meets the intake air, you establish a differential flow through the chamber that can be regulated for optimum burning at different flight speeds and fuel flows. The resultant pressure rise in the chamber also accelerates the combustion process.

Three kilowatts of electricity from 220-lb Snap II nuclear power supply

SNAP II nuclear power supply developed by North American weighs 220 lb and produces three kilowatts of electricity. Estimates are that production models would cost \$400,000 each.

GROUND SERVICING equipment needed for a large space vehicle with three liquid stages is staggering:

- **First Stage**—missile system checkout trailer; signal responder trailer; telemetering trailer; booster-section cradle assembly; emergency diesel generator; power distribution trailer; cables, slings, missile-erector trunnion assembly; missile-handling trailer; propulsion system test equipment; radio interference lab trailer; and maintenance platforms.

- **Second Stage**—checkout trailer; propulsion-system test equipment; helium heat exchanger; signal response trailer; cables, slings, erector assembly; hydraulic supply and checkout units; hy-

drogen peroxide storage and transfer trailer; telemetering checkout trailer; booster adapter trailer; and pressurization control unit;

- **Third Stage and payload**—fuel and oxidizer storage trailers; pumping and metering trailers; checkout trailer, air conditioning unit; handling trailer; propulsion-systems checkout console, cables, slings, lifting fixtures; and telemetering trailer.

Reliability research needed on gas generators

GAS GENERATOR designs could benefit from an intensive reliability research program. Many space vehicles and rocket aircraft depend on solid or liquid gas generators for non-propulsive power supply. The operational reliability of these generators leaves something to be desired.

Many X-15 failures, for instance, reportedly have been caused by burnouts, seal leaks, instability, and overheating in gas generators. Auxiliary system components like overload valves, relays, etc., also have been malfunctioning. It looks as though a program of design standardization and simplification is needed if we are to get truly operational equipment.

SPACE MEDICINE research is due for a shot in the arm. Many responsible scientists are seriously concerned over the lack of a coordinated research program on human factors when not only Mercury but also Dyna-Soar and manned lunar vehicles are in the late planning stage.

MONSTROUS SOLID BOOSTERS with more total impulse than Atlas and approaching Saturn in thrust (but smaller in size) have been proposed by Thiokol and Grand Central Rocket. They would weigh some 10,000,000 lb each and burn for 60-100 seconds. The propellant would have to be poured at the launching site.

UNMANNED SMALL SUBS have been proposed to patrol our coasts. The drone subs would cruise continually in fixed patterns and be guided to enemy targets by shore command or elaborate self-contained electronic seekers. Self-recognition and avoidance would be built in. On approach to a non-responding (enemy) sub, the drone would release "showers" of seeking torpedoes and or activate a warhead and itself home in on the target.

more on page 32

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WINGED RECOVERABLE booster studies were described to recent American Rocket Society Meeting in Washington, D.C., by D. J. Jones, Jr., and J. O. Tearnen of Convair-Astronautics. The booster would have small wings and could be piloted back to the launch site after the payload had been placed in orbit. For the boost phase, it would use rocket motors. After coasting back into the atmosphere, it would use an air-breathing engine for the final landing phase.

Low-radiation flight schemes proposed to get us through Van Allen belts

THE DISCOVERY of the Van Allen radiation belts has clearly shown that we must develop low-radiation flight schemes for safe travel through these belts in manned craft, Babinsky, Del Luca, and Bond, of Thompson Ramo Wooldridge's Tapco Group, told the ARS meeting. Their studies indicate that traversed payloads could be increased by a factor of 2 if they traversed the belts on electric power after a ballistic launch to a low altitude orbit instead of flying ballistically all the way.

A chemical booster of the late '60s, the Tapco engineers stated, will place a 150,000-lb payload in a 300-mile orbit or a 110,000-lb payload in a 2000-mile orbit. Their computation shows that the total radiation dose in travel through the Van Allen belt is less if the low thrust phase starts at 2000 miles.

However, the 40,000-lb payload advantage of a start from a 300-mile orbit cannot be overlooked.

THE EXTRA shielding and powerplant weight required for starts from 300 miles amount to less than 40,000 lb, Tapco engineers told the ARS. All in all, they declared, 300-mile starting altitude is more practical for low thrust traversal of the radiation belts at accelerations from 10-3 to 10-4 g.

Ballistic launch to 8800 miles altitude, followed by a low thrust phase, would tend to eliminate the need for heavy proton shielding, the Tapco engineers noted. However, 80,000 lb of payload would be sacrificed—and some shielding would still be needed.

■
IMPROVED COOLING system for spacecraft was proposed to the ARS meeting by Dr. J. H. Fisher and Charles Stevens, of Electro-Optical Systems, Pasadena, Calif. It uses a heat pump and

a cylindrical heat rejection radiator encompassing the entire ship (rather than major extensions of the vehicle surface, as proposed in other designs).

The proposed system has temperature regimes. It's claimed to decrease the total external vehicle area by 60 per cent and to increase the volume of the low temperature internal environment by 40 per cent (for 100 kw output, operation on a mercury Rankine cycle with 10 per cent overall conversion efficiency, a nuclear power source, a rejection temperature of 600 deg F, and an electric propulsion system that consumes 80 kw).

HEAT PUMP IS USED to maintain a 70-deg internal temperature. It dissipates 20 kw of thermal energy produced by the communications system and lift-sustaining processes, as well as energy "leaking" back through the high temperature outer skin into the low temperature (T2) compartment.

Two extra radiator areas in the system accommodate the heat pump. The first is needed to reject waste energy produced by the heat pump drive converter. This energy is rejected at the same temperature (T1) as the waste energy from the primary converter. The second area is needed to reject heat removed from the vehicle interior at temperatures (T3) lower than those of the primary-converter radiator.

ECM and recon A3D-2Q has air-conditioned crew areas pressurized to 7.5 psi

FIRST A3D-2Q rolled off the production line at Douglas' El Segundo (Calif.) Div. The craft is an electronic countermeasures and recon version of the A3D Skywarrior. It carries a flight crew of three and four electronic operators. Cockpit and cabin are completely air-conditioned and pressurized to 7.5 psi. The plane is powered by two P&WA J57s and has a range of over 2500 miles and cruise speeds of over 550 knots.

•
YTTRIUM can provide spectacular improvements in steel alloys, scientists from GE's Aircraft Nuclear Propulsion Dept. told a recent ASM-AEC symposium. An outstanding example, they stated, is AISI 446 stainless, which contains 25 per cent chromium and is oxidation-resistant to 2000 deg F. By adding a small amount (about one per cent) of yttrium, the GE scientists re-

more on page 34



Echelon of progress:

Here is the first jet trainer specifically designed to meet most of the Navy's jet training requirements in one airplane—the T2J Buckeye by North American Aviation. It is being used to school Navy pilots for the new era of Mach 2 carrier-based airplanes such as Navy's A3J Vigilante, which is also built by NAA.

Fifteen years ago pilots were trained to fly top-performance aircraft of 360 mph. Today 1400 mph and above is the order of the day. At speeds exceeding those of fighter planes of World War II, the T2J not only prepares pilots for this higher performance, but is capable of reducing the training schedule as much as a month.

T2J trains crews for Navy's new Mach 2 manned weapon systems

There need be no lost "transition time" between phases.

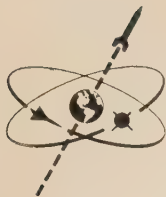
Pilot safety is a prime concern in T2J design. Its stall speed is only 80 mph and it lands handily at 85 mph. The instructor sits in tandem, behind and 10 inches higher than the student—and forward of the wing for maximum visibility. A rocket-catapulted emergency escape system—which has already saved lives in service—operates at all air speeds, even after touchdown.

Designed to meet the Navy's new concept of a single trainer to prepare pilots for high-performance jet aircraft, the T2J is in service today as the airplane that will match this concept for many years to come.

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ported, you get a new alloy whose oxidation resistance at 2500 deg F is as good as that of the conventional alloy at 2000 deg F.

If you add still another element—e.g., aluminum or thorium—you get even better results the GE scientists said. An FE-25Cr-Y alloy with three per cent aluminum, for instance, is said to provide an oxide coating at 2600 deg F that is “enamel-like, hard, non-chipping, and thermally shock-resistant.”

Alloy could be cold-rolled to strip with only slight edge roughness

IN OTHER STUDIES, the addition of 0.5-2 per cent of yttrium to unalloyed vanadium provided an alloy that could “be cold-rolled to strip with only slight edge roughness.” Vanadium without yttrium cracked extensively under cold-rolling.

ASTROLOY closed-die forgings, said to be the first successfully forged alloy parts, were announced by Wyman-Gordon. One part made on a 35,000-ton heavy forging press is an 26-in., 170-lb turbine wheel with an integral ring.

Astroloy, which was developed by GE, is a nickel-base superalloy, Wyman-Gordon states, that provides the highest strengths available in forgings. The company says that forgings can be made up to 40 in. in diameter. Guaranteed minimum mechanical (tensile) properties at 1400 deg F are 150,000 psi ultimate, 122,000 psi yield (at 0.2 per cent offset), 10 per cent elongation in two inches, and 12 per cent reduction in area. Room temperature ultimates are 190,000 psi guaranteed and 205,000 psi typical. Minimum guaranteed stress rupture for a smooth bar at 1800 deg F is 20,000 psi after 25 hours (with seven per cent elongation).

All-beta-titanium motor casing closures forged with closed-die method

WYMAN-GORDON also reported the successful closed-die forging of all-beta-titanium motor casing closures. One such forging weighs 441 lb and has an OD of 41.16 in.

P3V-1 ASW PATROL PLANE, the Navy version of the Lockheed Electra, completed its first flight

last month. The operational prototype of the fleet production units will be fitted with advanced Allison turboprops developing 18,000 hp on takeoff. The climb rate at combat weight will be 600 fpm on just two engines.

The P3V-1 has an elongated, cone-shaped tail that houses detection equipment. The Electra's airliner windows have been replaced by extra-large, observers' stations on both sides fore and aft to provide a full 180-deg field of view. The wing span of 99 ft is the same as for the Electra, but fuselage is 113 ft 7 in. against the Electra's 104½ ft.

SAME OLD ELECTRIC problems that plagued Henry Ford's Model T still bother supersonic aircraft, Brig. General W. E. Arnold, USAF's Director of Flight and Missile Safety Research, told the 43rd AF-Industry Conference on Flight Safety, at Palm Springs, Calif. Such common hazards as short circuits and stray voltage are key problems, he said. Besides generators, wiring, and batteries, the components that fail most frequently, he said, are inverters, relays, circuit breakers, switches, constant-speed drives, rectifiers, and wiring hardware.

New graphite has highly oriented, more advantageous crystal structure

HIGH TEMPERATURE Pyrographite material has been developed by Raytheon. A new process, claims the company, produces commercial quantities of graphite with a highly oriented crystal structure that results in thermal and electric conductivities that are more anisotropic (by several orders of magnitude) in the plane parallel to the surface than at right angles to the surface.

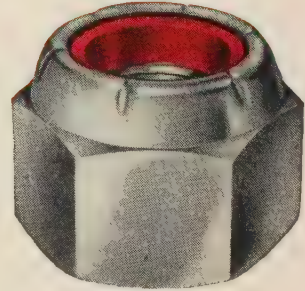
The material has shown densities as high as 2.22, though the usual range for densified graphite is 1.7-2, Raytheon says. The strength-weight ratio along planes, it's claimed is higher than that of 310 stainless steel at low temperatures.

PYROGRAPHITE is also said to have withstood highly erosive atmospheres, such as those produced by a high velocity, high temperature reducing stream of solids and gases that breaks down normal graphite. In other experiments, a mass spectrometer leak test after heating to 2500 deg C and recooling showed no permeation by helium even in films as thin as one or two mils. Thermal expansion is said to be 0.66×10^{-6} m/m/deg C.

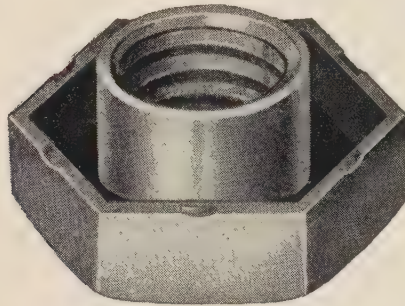
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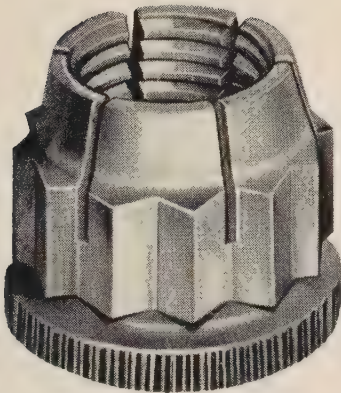
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calendar

January 11-13—Sixth National Symposium on Reliability & Quality Control in Electronics, Statler Hilton Hotel, Washington, D. C.

January 12-16—16th Technical Conference, Society of Plastics Engineers, Conrad Hilton Hotel, Chicago, Ill.

January 18-21 — Sixth American Astronautical Meeting, Statler Hilton Hotel, New York City.

January 25-28—28th Meeting, Institute of the Aeronautical Sciences, Hotel Astor, New York City, Honors Night Dinner, Jan. 26.

January 28-29 — Solid Propellants Conference, American Rocket Society, Princeton University, Princeton, N.J.

February 1-4—Winter Conference & Exhibit, Instrument Society of America, Rice Hotel & Sam Houston Coliseum, Houston, Tex.

February 3-4—Sixth Midwest Welding Conference, Armour Research Foundation & Chicago Section of American Welding Society, Illinois Tech Chemistry Bldg., Chicago, Ill.

February 3-5 — Winter Convention on Military Electronics, Institute of Radio Engineers, Biltmore Hotel, Los Angeles.

February 10-12—Seventh Solid-State Circuits Conference, IRE, American Institute of Electrical Engineers, & University of Pennsylvania, Philadelphia, Pa.

February 16-18—First National Symposium on Nondestructive Testing of Aircraft & Missile Components, Southwest Section, Society for Nondestructive Testing, Southwest Research Institute, Hilton Hotel, San Antonio, Texas.

March 10-11—National Flight Propulsion Meeting (classified) IAS, Cleveland, Ohio.

March 23-25—Symposium on Optical Spectrometric Measurement of High Temperatures, University of Chicago's Applied Science Lab, Jerrrell-Ash Co., National Science Foundation, University of Chicago, Chicago, Ill.

April 6-8 — Structural Design of Space Vehicles Conference, ARS's Structures & Materials Committee, Biltmore Hotel, Santa Barbara, Calif.

April 6-8—National Meeting "Hyper Environments—Space Frontier," Institute of Environmental Sciences, Biltmore Hotel, Los Angeles, Calif.

April 19-21 — International Symposium on Active Networks & Feedback Systems, Polytechnic Institute of Brooklyn, Dept. of Defense Research Agencies, IRE. Engineering Societies Bldg., New York City.

April 20-22 — National Symposium on Manned Space Stations, IAS, National Aeronautics & Space Administration, The Rand Corp., Ambassador Hotel, Los Angeles, Calif.

April 21-22 — Southwest Metals & Minerals Conference "Metals & Materials for the Space Age," American Institute of Mining, Metallurgical and Petroleum Engineers, Ambassador Hotel, Los Angeles.

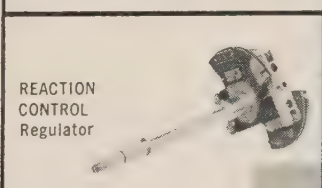
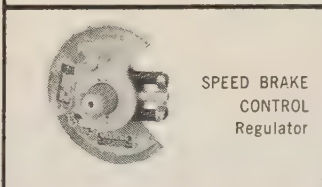
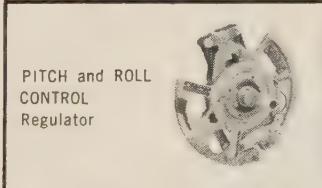
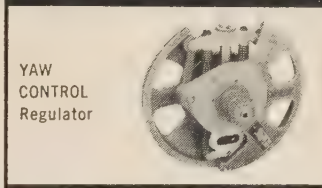
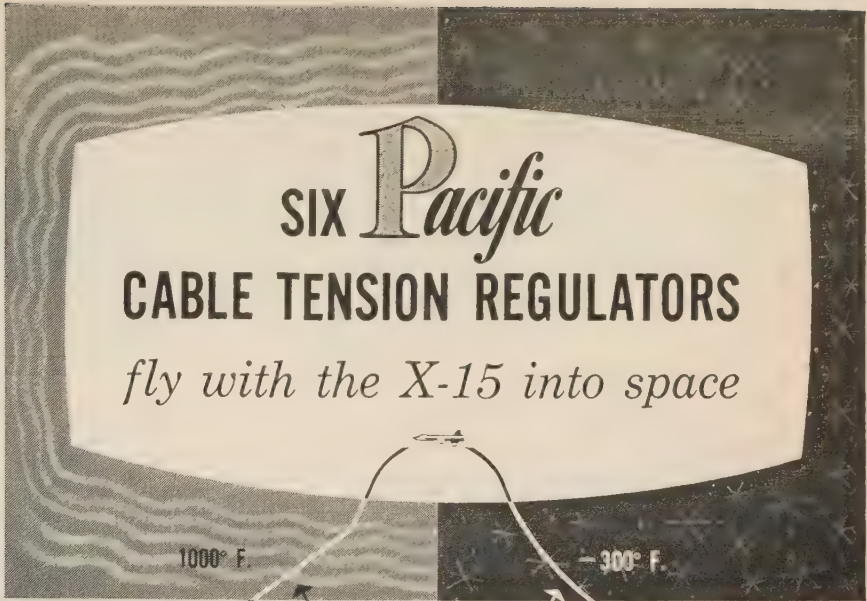
April 21-28 — American Society of Tool Engineers, "Ultra High Speed Machining & Explosive or High Energy Forming," Aeronautical Systems Center's Manufacturing Methods Div. of Air Materiel Command, Detroit, Mich.

April 25-26 — 18th SPI Canadian Section Conference, London Hotel, London, Ont., Canada.

April 25-29—Second Southwestern Metal Exposition & Congress, State Fair Park, Automobile Bldg., Dallas, Tex.

April 25-29—41st Convention & Exposition, AWS, Biltmore Hotel & Great Western Exhibit Center, Los Angeles, Calif.

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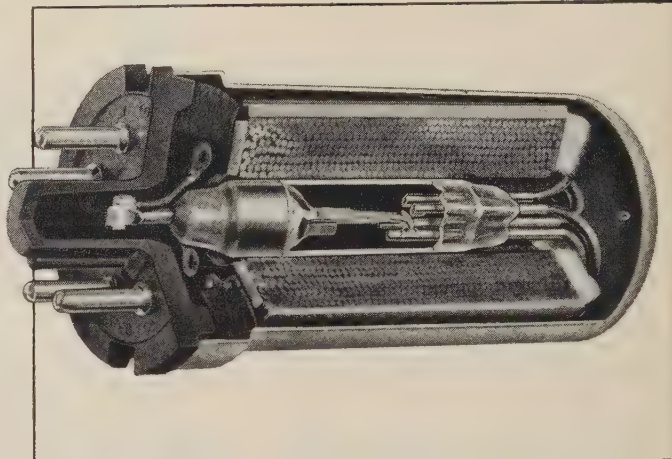
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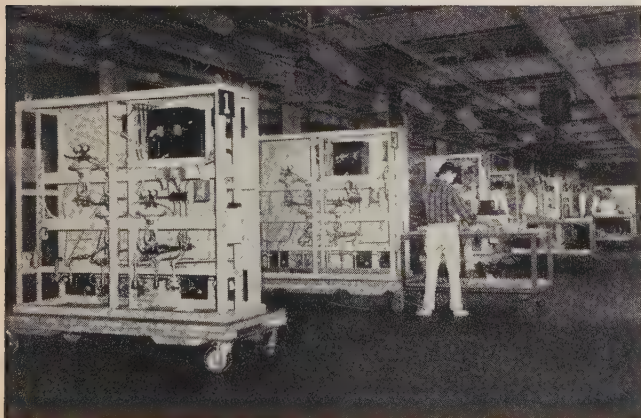
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SPACE/AERONAUT

Industry views the future of undersea weapon systems

by **Robert M.
Loebelson,**
Associate Editor

MANY OF THE MAJOR companies working in the undersea warfare system (UWS) area are convinced that the UWS development will be slow unless future budgets are readjusted. They are equally certain that a single government agency coordinating UWS work would be extremely helpful.

These are two of the more important findings of a SPACE/AERONAUTICS survey of industry views on UWS. Among the companies questioned were Aerojet-General, Chance Vought Aircraft, General Dynamics, Goodyear Aircraft, and Lockheed Aircraft. These firms all have set up special divisions, departments, sections, or groups devoted exclusively to UWS.

The firms covered by the survey all believe (and Navy officials agree) that the most critical technical UWS problems involve the classification and detection of deep-running, silent submarines. But not all expect their major UWS contributions in the next five years to come in this area.

Aerojet, convinced that "budget levels have reached the stagnation point," does not foresee "rapid progress" in detection and classification. Its contributions will probably involve "advanced torpedoes, rockets, and perhaps fighter submarines."

General Dynamics expects progress in UWS comparable to that in our space and air programs, but adds that it also will improve "in direct proportion to funding." It declares that it cannot say what its major contributions will be over the next five years.

Lockheed's Antisubmarine Warfare Systems Organization (LAWSO) predicts that the problems involved in finding and classifying enemy subs will probably result in increasingly complex UWS systems. It adds, however, that these systems need not be sophisticated but, if possible, should be simplified. It believes that the cost of improving existing techniques

more on next page

S/A survey gets
industry's viewpoints
on critical UWS
problems, growth
possibilities,
government leadership

S/A Goes Underwater

STRANGE as this title sounds, it's justified, for a lot of strange things happened to us in putting together this special report on undersea weapon systems. First we had to sell ourselves on the proposition that what happens under the ocean is of vital concern to the aerospace industry—a startling statement on the face of it but one that we now believe is literally true. Then we had to sit down and go back to school, grounding ourselves in the fundamentals of technical areas that we'd hardly given a thought to in the past. And when we finally were ready to go into the field and talk to engineers and scientists in companies, government groups, and university labs, we ran into more controversy and also more daring ideas than on any other special report we've ever done.

No matter how many strange areas we got into, though, we're sure that this special report is well worth the effort it took. For the same thing that had happened to small groups throughout the industry happened to our editors—once they had begun to understand the potential of undersea weapon systems and their tremendous technical challenge, they were hooked. The main problem of the special editorial team that worked on this project—Vic de Biasi (as project leader), Irwin Stambler, Jim Holahan, Bern Kovit, and Bob Loebelson—in the end was how to condense the encyclopedic amount of information they would have liked to present to do justice to their subject to fit the limits of 11 magazine articles.

Another strange development: We got into competition with the map-makers. Finding that, as far as we could tell, there exists no oceanographic map that brings together all the data of primary importance to undersea weapon system designers, Bern Kovit "simply" went ahead, got together all the necessary information, and drew up such a map. Printed as a four-color pullout, you'll find it on pages 53-56.

A limited number of reprints of this special report is available free of charge to meet single-copy and small-lot orders. For bulk orders, special rates will be quoted. In either case, please write to Reprint Dept., SPACE/AERONAUTICS, 205 E. 42nd St., New York 17, N.Y.

SPACE/AERONAUTICS' special report on undersea weapon systems begins with this article. The other articles in this report are:

New System Concepts Developing for Undersea Weapons	43
Catching Up with the Submarine	48
The Undersea Environment	51
State of the Art: Detection and Communications	58
State of the Art: Guidance and Navigation	64
State of the Art: Propulsion	68
State of the Art: Hydrodynamics, Structures, Materials	72
Cavitation Problems Loom Large in Underwater Missile Design	77
How To Build a Hydro-Acoustic Test Tank	89
Undersea Weapons System Roundup	101

Randolph Hawthorne

EDITOR

"may not be justified by the results," but adds that improvements must be studied before being eliminated as uneconomical.

Lockheed expects its greatest contribution in the next five years to be "a substantial improvement in search and detection that will utilize the potential for an increased search rate of the airborne anti-sub vehicle." Chance Vought agrees. It expects to help the Navy's UWS program by evolving "new detection techniques, a new sonobuoy system with new capabilities, and greatly improved anti-submarine aircraft."

Goodyear's attitude is that present UWS systems are technologically marginal. "Sophistication will grow," it says, but the results will still be marginal." It expects its major contribution over the next five years to include the Subroc anti-sub missile and breakthroughs in detection and classification field.

Almost every firm working in the anti-sub area makes long-range plans—and finds frequent revisions necessary. Goodyear tries to forecast 5-10 years ahead, but reexamines its efforts quarterly. Aerojet now projects programs for only 6-12 months and revises them monthly. It is considering lengthening its forecasts to 2-5 years, with quarterly or semi-annual modifications. Lockheed plans its programs annually but also makes projections for 5-10 years ahead. Chance Vought makes five-year forecasts, which it reviews and sometimes revises each quarter.

The surveyed companies all believe that there is a great engineering challenge in UWS but that the sales and profit potential seems small right now. Goodyear estimates that despite the obvious Russian submarine threat, only \$250 to 300 million is being spent on anti-sub warfare (ASW) annually (not counting the cost of our nuclear fleet). Within five years, though, perhaps a half-billion will be available, Goodyear thinks. Some companies are hopeful that after 1963 (when some major breakthroughs may be made), decisions by the National Security Council will up this figure to several billion a year. There is also some belief that work in the UWS area will have commercial applications.

No agreement on government setup

Differences in opinion showed up in the answers to questions about the Administration's handling of the undersea warfare program. Aerojet would like to see a single agency ("not necessarily a new one") handle anti-sub work with "responsibility and commensurate authority (money)." Lockheed also believed we could make better progress in ASW if we had "single, central agency through which all government ASW business with industry is conducted." Goodyear points out that too many agencies have pieces of the ASW program.

Slightly different views are voiced by General Dynamics and Chance Vought. G-D says, "All we ask for is for the Government to continue to keep an open mind on ASW problems and maintain its eagerness to get them solved." And Chance Vought explains that "the Government has been very cooperative" in making the work of its undersea-warfare department easier and more effective.

The men who head and work in the undersea-warfare departments of the firms queried by SPACE/AERONAUTICS have much in common. For the most part, they are specialists with a technical, analytical, or operational backgrounds in ASW. Many are former Naval officers;

others are hydrodynamicists, oceanographers, systems analysts; still others hold specialized doctorates in geophysics, acoustics, etc. Widely in demand by firms involved in ASW work are scientists and engineers with majors in mathematics, physics, naval architecture, mechanical, marine, electronic, and chemical engineering, and operations and systems research.

Some of the comments of SPACE/AERONAUTICS received in the course of its industry survey proved highly revealing, as the following selection shows:

Question—What prompted you to set up a special department or division for undersea weapon system?

Chance Vought—The decision to set up an ASW Department was made because of the obvious importance of ASW, the obvious need for R&D in this field, and the Navy's appeal to industry for assistance on ASW problems.

General Dynamics—L. B. Richardson, General Dynamics' vice president-engineering, organized the General Dynamics ASW coordinating group. Our goal was to marshal General Dynamics' full potential for helping to correct the growing gap between offense and defense in ASW.

Lockheed—ASW research is coordinated and directed by a department within the Engineering Branch of the California Division that is called LAWSO (Lockheed Antisubmarine Warfare Systems Organization). LAWSO was formed as a result of discussions between D. J. Haughton, corporate vice president, and Navy personnel, who impressed on him the need for ASW work by major competent corporations like Lockheed.

Propulsion research started in '44

Aerojet—Research in the field of advanced underwater propulsion systems was begun at Aerojet in 1944 by members of the Research Division. In 1951, the Research Division was reorganized and an Underwater Engine Division (UED) was set up. UED was reorganized and renamed the Anti-Submarine Warfare Division in January 1959.

Goodyear—We had been producing airships for ASW work for many years, and our ASW department was a natural outgrowth of our work in this field. The participants in the decision to create this department included Thomas Knowles, president; Hal Flowers, director of weapon system forward planning; several of our top engineering people; and Robert Richardson, vice president-sales.

Question—How do you view the future of underwater engineering programs in terms of technical accomplishments and of profit and business potential?

Lockheed—The future for ASW programs is unlimited so long as the submarine remains a threat. In terms of profit and business potential, ASW represents significant values for the future as it has in the past for Lockheed. Gross business in the ASW field at the California Division probably has been in excess of one billion dollars over the last 20 years.

General Dynamics—Answers to both parts of this question depend on how much the government wants to spend on ASW.

Aerojet—The future for underwater engineering appears to be quite bright, because its problems parallel engineering problems in air and space, which are receiving major emphasis at this time. Profit and business potential are another story. Defense budgets have not been readjusted to admit significant new underwater re-

search. Barring a Russian threat in the underwater world, we expect selling to be hard for the next several years.

Chance Vought—In terms of technical accomplishments, the future should bring:

- improved systems for the detection of deep-running, quiet nuclear submarines, probably involving electromagnetic, infrared, acoustic, and radio-active methods;
- extensive improvements in detection, classification, and identification of equipment by advanced electronic techniques;
- great improvements in surface sonar, particularly of the variable-depth type;
- greatly improved sonobuoys;
- improved anti-sub missiles and depth bombs;
- small hunter-killer subs;
- great improvements in technical communications systems, particularly between aircraft and subs;
- unmanned underwater drones and satellites remotely controlled or automatically programed.

Goodyear—Aside from the Subroc antisub missile, we expect our major contribution to be in the detection and classification area. This work could conceivably result in a 10-20 per cent expansion of our undersea warfare activities each year.

Lockheed—LAWSO is concerned with all aspects of ASW research and solicits technical programs in these fields. Work done by the Navy is revealed by published documents, regular association with Navy bureaus and offices in the course of business, and through organizations like NSIA, IAS, SAE, etc. New program opportunities are discovered in the same manner and by company-instigated proposals.

General Dynamics—General Dynamics and its divisions combine capabilities in every conventional phase of ASW, and we're exploring many non-conventional phases. Personnel are assigned to monitor progress in the state of the ASW art wherever it is taking place.

Aerojet—Our new ASW Division is interested in torpedo programs in all forms. We are also interested in systems that employ the growing capability of our ASW Division in the fields of propulsion (hydro-propellants), high speed underwater bodies, towed underwater vehicles, and applied research in wave and sound phenomena.

"Loosely organized reporting net"

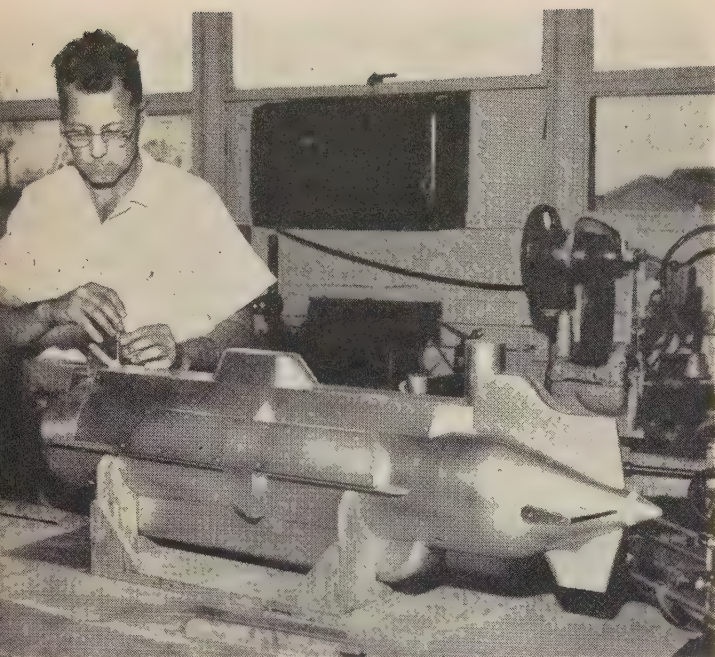
We keep track of work done by other companies through a loosely organized reporting net consisting of Customer Relations area coverage and specific technical coverage by qualified engineers, who attend symposiums and make business contacts with their working colleagues in their special fields. The Navy assists in a general way by periodically giving status reports in acoustics, underwater propulsion, torpedoes, etc.

New program opportunities are uncovered partly by unsolicited proposals, but mainly through an effort to match our technical capabilities to well-defined problems on which the Navy occasionally briefs industry.

Question—What kind of technical work is your UWS department trying to get? How do you keep track of work done by other companies and by the Navy? How do you find out about new program opportunities?

Chance-Vought—Technical programs already received include study contracts for advanced detection

more on next page



TYPICAL of the aerospace industry's contribution to underwater research is the Aluminaut, developed by Southwest Research Institute and to be built by Reynolds Aluminum. It will provide almost 100 hours' undersea endurance at depths of more than 15,000 ft.

methods and ASW aircraft and a new, as yet unannounced development contract. Programs aimed at in the near future: new detection methods, ASW aircraft, and anti-submarine missile systems.

The ASW Department keeps track of ASW work in progress at other companies through visits, technical reports, industry publications, and joint efforts. To keep

track of Navy ASW work, close liaison is maintained with cognizant offices in BuWeapons, BuShips, and CNO. Knowledge of new program opportunities is obtained by continuous evaluation of current ASW requirements and developments.

Goodyear—We are trying to line up work on detection and classification, weaponry, and carriers for weapons (airships, drone inflatoplanes, and drone ground-effect machines). Our primary way of finding out what competitors are doing in the underwater area is through the military. New program opportunities are unearthed in several ways, including the Navy's annual list of long range planning objectives.

Question—Was it hard to recruit engineers for your UWS department?

Lockheed—Since LAWSO is a directing and coordinating agency for ASW research in the vast Lockheed organization, its efforts represent the combined skills, contributions, and energies of several thousand technical personnel engaged in that work. The direct department employees are, for the most part, system-oriented, with technical, analytical, or operations backgrounds in ASW. Some are former Naval officers, while others were selected for their Lockheed experience. Some highly specialized technical skills (such as oceanography), not generally found in the Lockheed California organization, are represented by employees specifically hired for the purpose.

General Dynamics—We are making use of the varied and extensive talents which exists in all of our divisions as the need arises.

Chance Vought—It is difficult to obtain engineers and scientists with sufficient experience and technical capability in the required work areas.

Aerojet—We have had some difficulty in recruiting qualified technical personnel for our ASW Division. This can probably be attributed to the fact that, until rather recently, underwater engineering and its related areas have been neglected and did not offer substantial promise of a rewarding career.

Five Companies—Five Definitions

What is an undersea weapon system? Even the major manufacturers who have set up groups to work on such systems area can't agree on a definition. Here's how five firms attempted to define undersea weapon systems:

Aerojet-General—"An undersea weapon system might be defined as a working assemblage of components suitably matched to perform a given underwater objective. For instance, a torpedo weapon system includes the torpedo itself, fire control equipment, handling equipment, launching equipment, and specialized components to permit the torpedo to effectively carry out its mission of seeking and destroying a target."

Chance Vought—"An undersea weapon system includes the detection, surveillance, and localization equipment as well as the actual kill weapon. It is therefore comprised of aircraft, surface ship, and submarine equipment."

General Dynamics—"Any concept, plan, weapon, device, theory, or approach to the defense of the U.S. against enemy sub attack comes under the heading of 'anti-submarine warfare.' This area includes, but is not

limited to, surface, air, and underwater craft engaged in attacks on submarines, submarine-launched ballistic missile systems, offensive and defensive underwater mines, as well as surveillance systems established in the sea or at the water's edge for the detection of underwater activities."

Goodyear—"An undersea weapon system is a weapon fired completely underwater, underwater-to-air-to-underwater, or from an aircraft or surface vessel. The basic objective of an undersea weapon system is to kill submarines. But such a system could also be defined as anything that causes an enemy nation to expend money or manpower. One example is Russia's use of its 400-odd subs for psychological warfare and propaganda."

Lockheed—"Undersea weapon system is a combination of words not in general use at Lockheed's California Division. 'Anti-submarine warfare systems' embody all aspects of technologies, logistics, operations, costs, requirements, and equipment used in seeking, classifying, destroying, deterring, or encumbering unfriendly or enemy subs."

New systems concepts developing for undersea weapons

Whole families of underwater vehicles?
Weapon-systems approach looks promising

Submarine teams are in the offing

by **Victor de Biasi,**

Associate Editor & Project Leader

NOT TOO LONG AGO, only a few people dared to predict that missiles would ever have the tremendous effect on our defense structure and the aerospace industry that they actually have had. Yet those few visionaries were right. Today, the military and the industry are confronted by a comparable daring new "vision"—undersea warfare.

The full technical potential of undersea warfare is still hard to pin down. But there is little argument about the grave military threat of an attack launched from under the ocean. It is this threat actually that has prompted most of what limited scientific work has been done on undersea-warfare problems.

It is understandable that our efforts right now should be concentrated on better defenses against submarines. But why stop at this point? There is no technical reason we could not develop whole families of underwater attack vehicles and weapons just as we have in the air. And there's a lesson we can draw from the history of

aviation: If we had concentrated on the development of anti-aircraft warfare and neglected the aircraft themselves, even the supersonic plane would probably still have to be developed.

It is entirely conceivable that some day missiles and space stations may become so effective that they virtually will put aircraft and surface ships out of business. If that happens, the submarine may be the only other vehicle that can carry out military missions with any success (assuming, of course, that submarine developments stay one step ahead of detection and interception techniques).

So long as a non-air-breathing sub moves quietly, it can remain invisible. Any experienced Navy man will tell you that it is practically impossible to pinpoint an uncooperative, deep submarine—even when you know its general area location.

Their cloak of invisibility gives high performance underwater vehicles an awesome potential. Imagine what a Mach 2 bomber or fighter could do if there were no such thing as radar to detect it!

Suppose then that, instead of the submarine as we know it, we had small recon, medium-size interceptor, and giant bomber subs. Suppose we armed them with external missiles or gave them drone escorts. Eventually, they might even be backed up by unmanned satellite stations or ocean-bottom armories to carry out preprogrammed missions upon command.

Blue-sky thinking does not solve today's problem, though. The Navy is boxed in by almost overwhelming responsibilities. It has a huge surface fleet to maintain, an air arm, and now an underwater arm of steadily increasing size. What it doesn't have is enough money.

more on next page



Special Message from Admiral Arleigh Burke, Chief of Naval Operations

SPACE/AERONAUTICS magazine is performing a most valuable service by preparing a special report on anti-submarine warfare. The problems with which the Navy is confronted in this vital field are very difficult, and we are exerting every effort in trying to find solutions for them.

Work in anti-submarine warfare must of necessity be a painstaking and sometimes tedious operation. Long hours are spent in analyzing data in an effort to improve methods of detection and to find effective measures to counter tactics which submarines may use now and in the future.

Too many people misunderstand the emphasis the Navy is placing on anti-submarine warfare. With Russia having over 400 submarines, there are some people who feel that we must have an equivalent number of submarines to be on par. This is not reasonable. If the Russians have a great number of submarines, then we must place stress on measures to counter the threat posed by those submarines—not to match them. We must counter the threat, not the means by which that threat is extended.

There are two particular areas of anti-submarine warfare in which we must increase our efforts: detection and underwater communications. We need improvements in both fields, and we need them as soon as possible.

The Navy appreciates the interest SPACE/AERONAUTICS has in this field, and we feel quite certain that the attention SPACE/AERONAUTICS' editors are giving to anti-submarine warfare, in this issue especially, will contribute to the solution of some of these very difficult problems.

Arleigh Burke

Actually, the Navy has more of a management problem on its hands than a technical problem. It simply cannot keep doing business as usual and meet all its obligations.

Several courses of action are possible. One would be to cut the undersea-warfare branch adrift and let Congress fund it on an equal footing with the traditional services. This approach might work, but it would not make many people happy. You also lose the in-house effectiveness of integrating the submarine with surface and airborne forces.

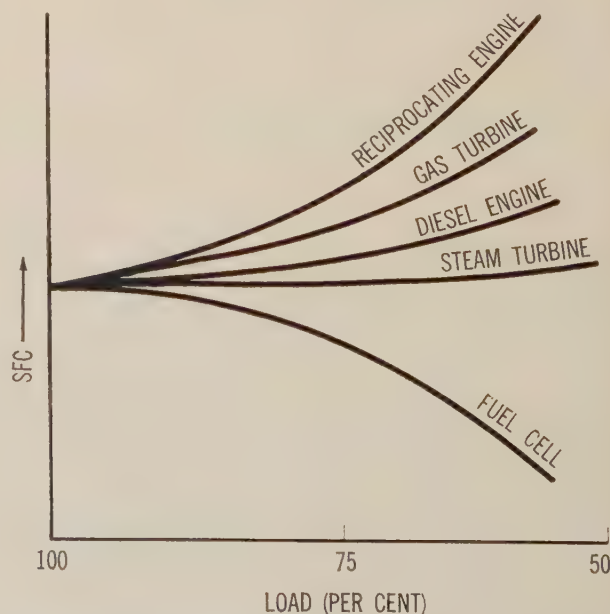
Another solution would be to limp along and patch up the present system on the basis of continuously shifting priorities. This stifles technical growth but will work as long as the enemy does the same.

Change all the variables at once?

A more drastic approach would be to consider the effects of changing all the variables at once. Analyze the entire Navy's operation as though it were to be set up from scratch and study the implications of possible organizational and operational changes in the light of the latest technological developments. This tack, of course, offers the least chance of success, because the opposition will be fierce. But it might be worth a paper study.

Assume the Navy finds it could carry out its major missions with three basic types of vehicles, all of which actually are already under development: hovercraft, hydrofoils vehicles, and subs. Assume further that each of these three types could be built at minimum cost in three size ranges to perform different missions.

Perhaps we could develop standard integrated control systems, powerplants, weapons, accessories, and support equipment. In short, consider changes not only in vehicles but also in equipment and operation.



DEMAND CONSUMPTION makes fuel cell systems for subs attractive from the standpoint of fuel economy. All other energy sources are less efficient under low-power demands (which prevail during most of the mission) than under near-peak demand.



ACTIVE SONAR SITES on the continental shelf, shown here for the Middle Atlantic coast of North America, could serve as an "underwater Dew line" to spot enemy subs. Plans to install giant transducers on the ocean

bottom, feed power to them through cables, and blast the ocean with huge sonar arrays have been reported. Vertical exaggeration of this map, which also shows some typical ocean bottom features, is about 20:1.

Our study might show that we cannot maintain our present equipment and also make the most of new discoveries and developments. In that event, it might pay to de-emphasize current production, depend on our allies to hold the line, and go on to the next generation—much the same as the Russians are believed to have proceeded in the case of their missile program.

Many will feel it presumptuous of anyone outside the Navy to make suggestions of this kind. But it should be rather obvious that nothing is more important for us today than finding some way of exploiting whatever technical leads we have at a cost we can afford.

The decision must be made now. By 1965, most of our present ships will be ready for retirement. And five years certainly isn't too much lead time for research, development, and production of "new" systems.

The aerospace industry's weapon-systems approach may be just what we need if we want to come up with mission-bred, integrated undersea vehicle designs. Right now it takes as many as 116 men to operate subs that carry less of a weapon payload than the B-36. With integrated subsystems and automatic control, it might be possible to cut the crew to 10 or 12 men. One

hundred men less make a tremendous difference in payload, size, supplies, cost, and expendability.

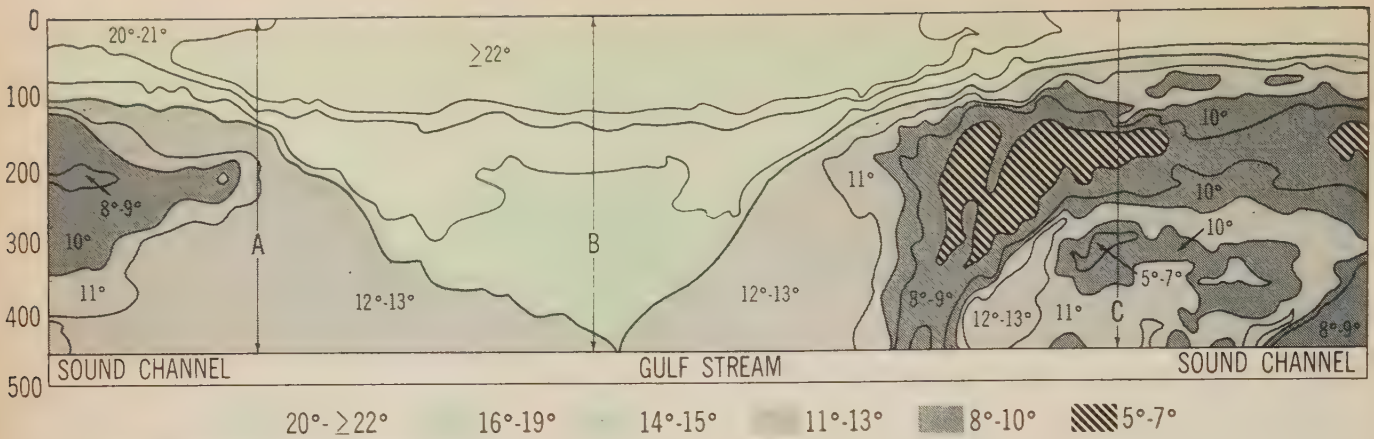
Why not design ships so that the entire powerplant can be replaced as a section, much as an engine in a plane? If a sub gets into trouble, why not have the crew "bail out" in a control capsule?

Experienced shipbuilders and Navy old-timers smile tolerantly at suggestions of this kind. These proposals obviously run counter to the Navy doctrine of self-sufficiency afloat, which says you should be able to repair anything from a fire control system to a leaky head. But there is no reason why this doctrine cannot and should not change.

One thing the Navy's departments will not stand for is having individuals or companies barge in and tell them how to run their shop. If companies in the aerospace industry are to make any contributions in the development of undersea vehicles and weapons, they would be ill-advised to become impatient with the way the shipbuilders and the Navy operate. They must learn to understand the problems of the Navy and to work with the Navy in finding solutions for them.

The Navy is used to working with companies that

more on next page



WIDE TEMPERATURE VARIATIONS in the ocean, shown here for a 26-mile-wide cross-section of the Gulf Stream, affect the velocity of sound. The sound channels, especially favorable for transmission, run roughly alongside

have had its interests at heart for many years, companies that know the Navy's problems intimately and have an outstanding record of accomplishments. It will take a little time before any "newcomers" are fully accepted—especially since in some Navy quarters they are slightly (and rather unreasonably) resented for "trying to cash in on a good thing."

What are the fundamentals of undersea defense? Surveillance, detection, identification, tracking, intercept, and kill—the same as in air defense. Attack can mean anything from launching long range ballistic missiles to sending up short range homing missiles.

A number of truly advanced defense systems appears to be feasible. Reportedly, we are already working on lining our continental shelf with transducers to detect oncoming enemy subs at long range. Another idea would be to carry sonar detection sites to the enemy. Skimmer-type hovercraft and hydrofoil vehicles moving at 100-knot speeds could cover a giant grid quite effectively. At the grid site, such a craft would settle in the water and lower a string of transducers to sample several depths. (Over very rough waters, a skimmer could use its air cushion at the expense of hovering endurance.) In this way, you could get a three-dimensional fix on suspected targets. After positive target identification, missile-carrying skimmers and hydrofoil craft would come in for the kill.

Subs attack without local help

Submarine attack in enemy water or under enemy-controlled skies will have to be carried out without local surface help. It seems reasonable to expect that different types of subs will be developed to carry out different missions. Several types could then be teamed to make up a fighting force.

Polaris-type submarines are in a class of their own—they are designed to operate as lone wolves. But you could visualize several small, defensively armed recon subs operating in teams of two well forward of a large missile attack submarine to spot likely victims.

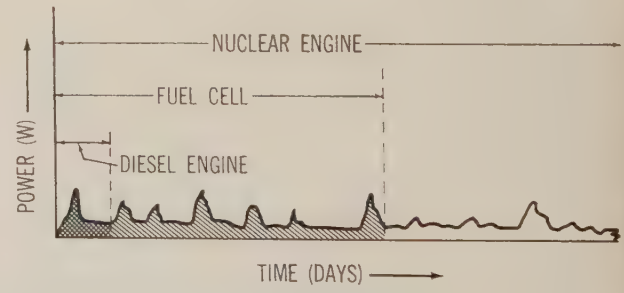
Once a target is positively identified, the recon team would have to reveal its presence by communicating with the missile sub. This might be done by transmitting on a transducer lowered to a preselected deep

sound channel or by raising an antenna. In either case, chances are the communication will alert the enemy. But by then he would no longer have time to escape.

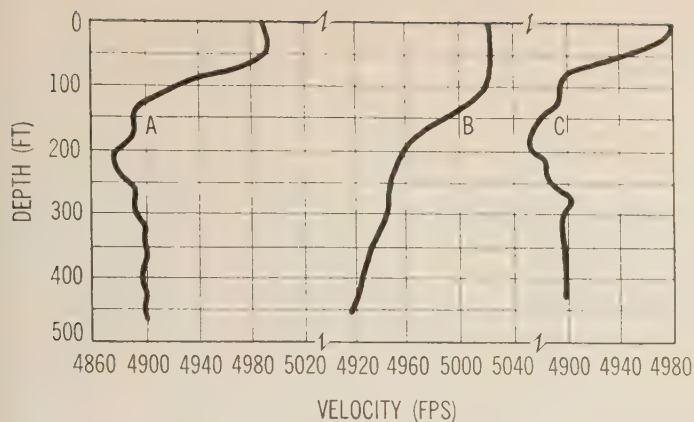
Bearing data on the target and a common reference would enable the missile sub to calculate the target's coordinates. The reference might be a sound transmitter released by one of the recon subs in the direction of the missile sub. The transmitter could send out timed pulses, one horizontally and the other bounced off the ocean floor. Meanwhile the recon subs would be sending bearing data on the reference and the target. Knowing the time interval between transmitted pulses and the time delay in their reception, the missile sub could determine the range of the reference and go on to lay out the target coordinates.

In a matter of seconds, a missile could be launched into the atmosphere to land in the general vicinity of the target. During the missile's water entry trajectory, the recon subs would focus active sonar on the target, so that the missile could home in on the reflected energy.

The advantages of such a system are that the recon subs could be small and elusive. They could be built in great numbers and fairly cheaply and they could be as expendable as aircraft. They might even be ferried

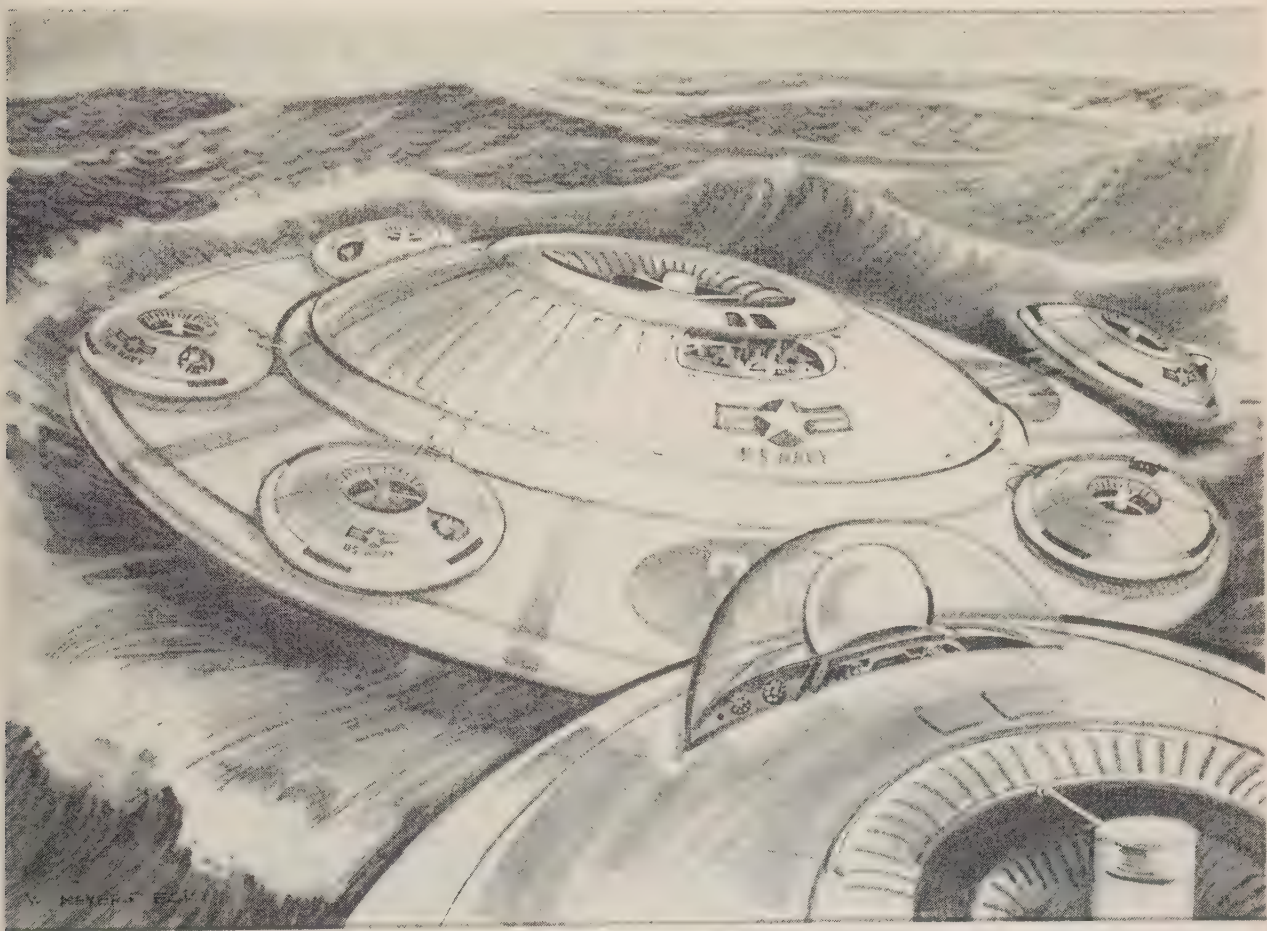


DUTY CYCLE for a submerged sub shows intermittent demands for peak power. Nuclear power, which extends the operating period indefinitely, has obvious advantages for Polaris-type subs. For small fighter and recon subs, a fuel cell, which reportedly will supply enough power for 30 days' submerged operation, or some similar system might be most effective.



the Gulf Stream. Besides temperature, density and salinity are important parameters of the ocean environment.

ULTIMATE SYSTEM of skimmer craft for ASW missions might use a giant design big enough to operate regardless of sea state and serving as a base for smaller skimmers. Since operations from the carrier skimmer would have to cover only relatively short ranges, the small skimmers could afford the high fuel consumption involved in flying over rough sea. Fuel would be stored in the fuselage of the carrier skimmer.



by hydrofoil vehicles or missile-armed convoys. The trend in submarine performance is to go deeper and faster. Missiles launched from deeper and faster subs will have to withstand terrific pressures (or else the sub will have to change levels for launching). The same will hold true for any missile designed to seek out

these subs. Below certain depths it will probably pay to carry external armament rather than to attempt leak-proof openings in the hull. In such an arrangement, the missiles probably would have to be filled with oil to keep them from being crushed under compressive loading.—End

3

Catching up with the submarine

Physical conditions stacked in favor of submarines

Effective submarine detection feasible but far off

ASW weapon development making good progress

by **Paul Cohen,**

Anti-Submarine Warfare Section,
Sperry Gyroscope Co.*

NUCLEAR POWER has given today's submarine endurance and mobility orders of magnitude beyond that of its snorkeling, diesel-powered predecessors. The solid propellant ballistic missile with a nuclear warhead has given it a destructiveness without precedent in naval warfare. In fact, a single Polaris sub can carry more explosive energy than has been used in all the wars of the world.

It's not hard to see that today the submarine threat is frighteningly greater than at any time in the past. And things are not getting better—the rate of technical progress in anti-submarine warfare (ASW) is slow compared to that of the submarine itself.

We cannot blame lack of funds or of talent for the slow development of ASW. The physical effects on which ASW equipment depends have been examined again and again in the light of every little advance made in instrumentation. New information on process-

*Sperry Gyroscope Co., Great Neck, N. Y.

Triton (415 ft, 5650 tons)



Thresher (274 ft, 3250 tons)



Skipjack (252 ft, 2830 tons)



Tullibee (260 ft, 2175 tons)



Skate (268 ft, 2360 tons)



ing theories and sophistications in circuitry are quickly brought to the attention of ASW engineers. No, the major obstacle to ASW progress is that the physical world itself seems to conspire to protect the submarine.

We desperately need a breakthrough to solve the basic problem of ASW: finding a submerged submarine. Not that this is impossible. A sub creates a multitude of secondary effects as it moves through the water (see *"State of the Art: Undersea Detection,"* p. 57). Some day, measurement techniques may become sensitive enough to seize on these effects, even at a considerable distance, as dependable clues to the presence of a submarine. When that happens, it may easily put the submarine back on the defensive. But it hasn't happened yet. For the present, therefore, the outlook for ASW is gloomy.

The primary defense of the submarine is its invisibility. It can hide under the surface of the oceans, which are very large, very deep, and virtually opaque to all electromagnetic radiation. The immensity of the oceans, which cover 70 per cent of the earth's surface, is the first deterrent to effective ASW. Right now we have no scanning technique giving enough range so that a practical number of scanning vehicles (surface ships, aircraft, submarines) could guard a moderately large oceanic area like the Bay of Biscay, let alone a major ocean.

In World War II, airborne radar could rapidly scan large ocean areas for subs lying on the surface to recharge their batteries. Today, the battery sub can use snorkels to reduce their radar-reflecting surface to a few square feet. In a few years, even these slight above-water projections will be rarely used—nuclear subs, whose powerplants need no oxygen, can stay submerged indefinitely.

Ocean is continually in motion

Another natural deterrent to detection is that the oceans are rarely calm. Each of the many forms of bad weather—fog, storm, snow, rain, and so on—in its own way hampers ASW. (Even good weather isn't necessarily good for ASW—brilliant sunshine interferes with infrared detection.)

Weather is a problem even before you get to the actual ASW equipment. If we ignore hydrofoil craft, which have yet to prove their sea-keeping capabilities, a ship must have at least 1000 tons displacement to keep at sea under a wide range of weather conditions. Winter seas in the North Atlantic, to take an example, average about state 5—about half the time, the waves are 10 feet high or higher. Even if a ship can take this kind of weather, its efficiency as an ASW unit falls off a good deal as the crew tire under successive days of continuous ship motion.

Nor are aircraft much better off. By and large, only the larger ones have all-weather capability. Helicopters, the ideal ASW aircraft, are quite dependent on weather and light conditions.

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U.S. Nuclear Subs

The U.S. Navy's first nuclear submarine was the pioneering, "one-of-a-kind" Nautilus, commissioned in 1955. Next came the Seawolf, like its predecessor a special developmental model designed for attacking surface craft.

In December 1957, the Navy commissioned the first production A-sub, the Skate, also an attack submarine. Since then, four more subs of the Skate class have been commissioned.

As the next step in nuclear submarine planning, seven attack subs of a radically new design and one giant radar picket sub were ordered. The prototype of the new attack class is the Skipjack, whose shark-shaped hull and single propeller produce high sustained underwater speeds and improve the craft's maneuverability. The last of the seven subs of the Skipjack class will be commissioned by the end of this year.

The radar picket design is the Triton, which, at 5900 tons, is said to be the largest sub ever built. It was commissioned last November. Fitted with high power radar and sonar, it will run ahead of high speed carrier task forces to detect and report on approaching enemy planes, subs, and surface vessels.

Also commissioned last year was the Halibut, the first nuclear sub to carry a guided missile. It can fire the air-breathing Regulus from the surface.

Nine models of an advanced version of the Skipjack have also been ordered. All these attack craft, known as the Thresher class, are to be commissioned this year.

The need for combating enemy submarines in their own environment led to the construction of a nuclear-powered killer sub, the Tullibee, to be commissioned this year.

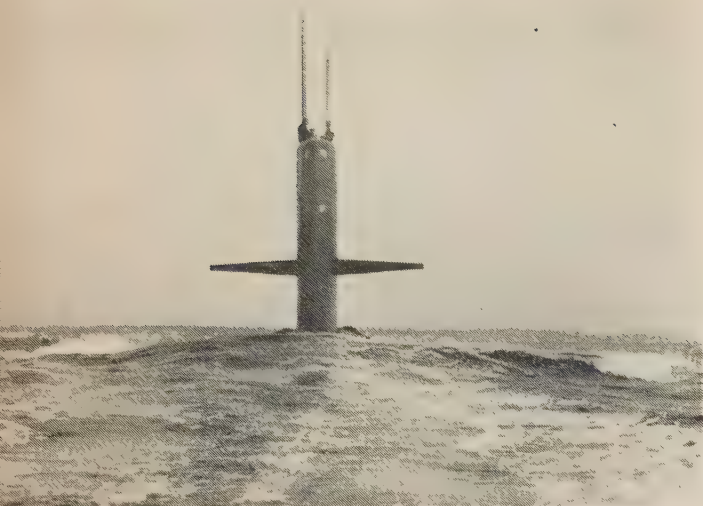
The Polaris ballistic missile will be the armament of the "fleet ballistic missile" (FBM) submarines, designed expressly as missile carriers and launching platforms. The first of these subs, the George Washington, will become operational this year, and so will the next two. Another six FBM subs are on order.

Halibut (350 ft, 3555 tons)



George Washington (380 ft, 5400 tons)





In contrast, a sub couldn't care less about weather. Submerged below the regions appreciably affected by wave action, it can always achieve its rated performance. This is why, in heavy seas, an 18-knot submarine can outrun a 35-knot destroyer.

Not surprisingly, submarine designers and crews are not disposed to give up the advantages of invisibility. Rather they have what amounts to a phobia about radiating signals into the environment. As much as possible, a sub operates only on passive information in detecting and tracking both surface and submerged targets.

Surface ships, on the other hand, can't hide as easily. If their target is submerged and quiet, only active sonar will reveal it at long range.

Largest sonars compare with radars

Today's largest sonar transducers and circuits (which include continuous wave, frequency modulation, and Doppler types) can handle about as much average power as can radars. Wave lengths are comparable, but sonar pulses for many reasons are much longer than radar pulses. Some sonars are so large that it almost takes a cruiser to mount them.

High frequency sonars far above the audible range give reasonably good resolution but they have only a short range and are quite sensitive to turbidity. Low frequency sonars have longer ranges but are massive and need such large domes or hydrodynamic shielding structures, that they interfere with the speed and endurance of the carrying ship.

Acoustic transmission runs into lots of problems posed by the ocean environment. Sea water is layered in terms of temperature (which can change sharply within a few feet of depth) and, less commonly, in terms of salinity. The surface and the bottom of the oceans both are irregular and sometimes changeable. The waves of the ocean therefore follow complex paths marked by heavy refraction and reflection that can blank out or distort signal transmission and reception.

The oceans also are full of acoustic noises, both

WHAT NUCLEAR SUBS can do was shown by the Skipjack when it broke all sub speed records on its maiden voyage. It is the first of a new class of attack subs, of which seven have been ordered. The last of the Skipjack-class subs is to be commissioned by the end of this year. Built by Electric Boat, the Skipjack has a shark-shaped hull, diving planes on the sail (formerly known as the conning tower), and a single propeller.

physical and animal in origin, and of non-homogeneities that sometimes are acute enough to reflect like a target. And on top of all these natural detection problems come those of man-made decoys.

Magnetic detection is effective, but mainly only over short ranges. Most of the ocean is deep enough so that wrecks, which might "look" like targets, are not a problem. Nor, with rare exceptions, are magnetic anomalies sharp enough to be troublesome.

Countermeasures, such as degaussing, can limit magnetic detection. And, of course, if submarines were to start using plastic, aluminum, or other non-magnetic hulls, they would be very hard to find magnetically.

Subs can be attacked in many ways

Weapons constitute the only ASW area that is in relatively good shape. As in making a rabbit stew, the problem disappears once you have the rabbit. If you've pinpointed the submarine, you can attack it with a variety of weapons: conventional and nuclear depth charges, torpedoes, and rocket missiles with ranges from a few hundred to many thousands of yards.

Basically, weapons are on hand or can quickly be developed to meet the range capabilities of any reasonably precise detection system we can foresee. Still, we must not forget that submarines, which in World War II could dive to no more than 600 ft, can now be built to reach depths measured in thousands of feet.

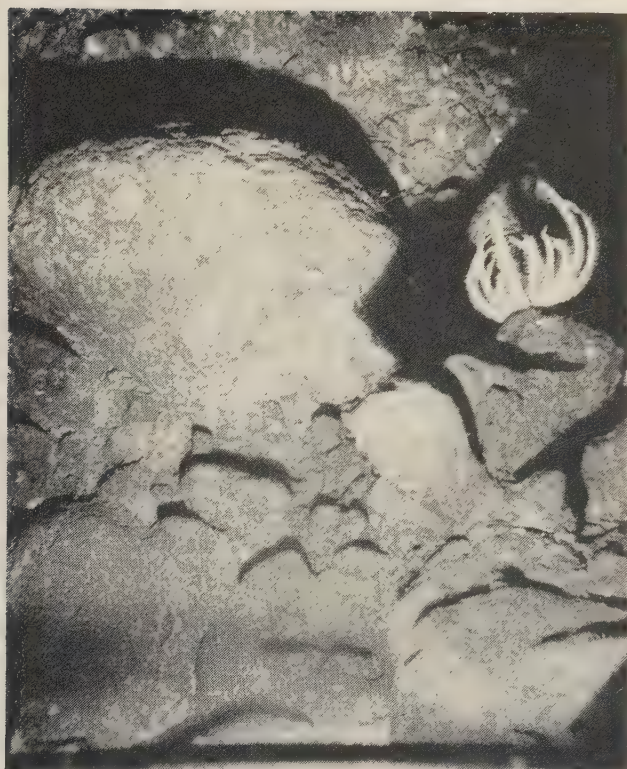
This greater vertical mobility adds to the problems already posed by the density of water, which is over 800 times greater than that of air at sea level. It is difficult and wastes energy to make undersea weapons move fast. Nuclear subs can already attain underwater speeds that are uncomfortably high compared with those of present ASW torpedoes.

Sinking a 30-knot sub poses problem

It is one thing to overtake and destroy a submerged submarine at six knots. It is quite another problem to defeat a 30-knot sub that usually knows where the searching ship is long before its own presence has been detected.

ASW undoubtedly has made progress, but the sub is making even faster progress. Helicopters and dipped sonars have increased the effectiveness of surface search (yet not enough to make a basic difference). Sonar ranges have been extended quite drastically over the past decade—in some cases by hundreds of per cent. But the faster, tougher sub of the future, which will stick nothing more than a periscope or an antenna into the air, remains a threat that today's ASW techniques show few signs of challenging.—End

The undersea environment



SEA MOUNT surface photographed at a depth of 683 fathoms shows a starfish and encrustations on rock that are produced by bryozoa, a low form of marine animal life existing in moss-like colonies. Sea mounts are isolated peaks that rise 500 ft. or more above the ocean floor and are characteristic of the upper continental rise.

Changes of the ocean bottom important to designers

Temperature, density and salinity must be considered

by **Bernard Kovit,**
Associate Electronics Editor

OCEANOGRAPHERS readily admit that so far we have only a fraction of the knowledge we ought to have of the undersea-warfare environment. Many details of the ocean bottom topography as well as close predictions of the distribution of the ocean's complex physio-chemical variables today are largely matters of inference.

Progress in oceanography is a painstakingly slow and gradual process of data gathering. "Tenoc", a projected ten-year program for the closely coordinated, well-funded buildup of ocean research facilities, should go a long way toward providing us with better data on the principal characteristics of the undersea environment. But these data will still be fundamentals, the bare minimum we need to gain a technological foothold in the medium.

In marine geology—the study of the physical details of the sea floor and the earth's crust beneath it—we probably have already made relatively good progress. The prospect of having to survey about 71 per cent of the earth's surface that is hidden under a miles-deep layer of water bring to mind complex instruments and involved theories. Actually, research technology and methods in this area are comparatively unsophisticated. Relatively few meth-

more on next page

ods and simple instruments are used, which moreover have the advantage of being rather close to first principles.

The *Chart of the North Atlantic Ocean* (p. 53) shows the three major divisions of the Atlantic—continental margins, ocean basin (floor), and mid-oceanic ridge. Each covers about one-third of the ocean's total area. Because the smoothing effects of erosion are relatively weak in the deep sea, the relief of the ocean floor is greater than that of land.

The continental margins consist of shelf, slope, and rise. The continental shelf, a relatively shallow (zero to 100 fathoms) submarine terrace that borders the continents in some regions extends seaward as far as several hundred miles. It ends in an abrupt decline or slope, at which the average depth of roughly 100 fathoms suddenly increases to anywhere from 700 to 1700 fathoms. The average shelf-bottom gradient of about 0.1 deg. gives way to a slope average of over four degrees. At the base of the slope you find a sharp change in the seaward gradient from less than one degree to less than 0.25 deg., which defines the beginning of the continental rise.

The surface gradients of this gently sloping apron vary from under 0.25 deg. to about 3.5 minutes. A number of sediment-laden submarine canyons and scattered protruding sea mounts characterize the upper continental rise. In some regions, the base of the rise is marked by a range of short hills (100 fathoms high or less).

Sediment layer may be miles thick

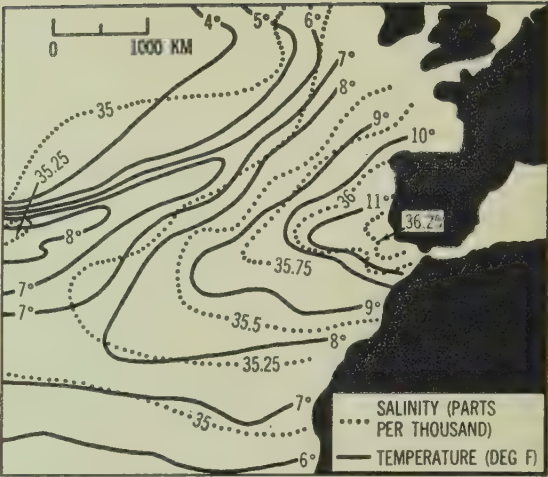
Seismic-refraction studies show that underneath the upper part of the rise there is a deep layer of sediment, which in places is miles thick. It actually fills trenches that probably are analagous to the unfilled, deep trenches bordering the Pacific basins or to the South Sandwich trenches of the Atlantic.

The continental rise gives way to the abyssal plains, probably the flattest surfaces on earth. Their almost perfectly smooth topography is attributed by Bruce C. Heezen and Maurice Ewing, of Columbia University's Lamont Geological Lab, to the deposits of sand and silt carried down from the continental margin by turbidity currents.

The principal positive topographic feature of the Atlantic undersea environment is the Mid-Atlantic Ridge, a 1200-mile-wide fractured swell that is a sector of the mid-oceanic ridge system running through the Atlantic, South Pacific, and Indian Oceans (Fig. 2). Extending along the entire length of the Atlantic, it is surmounted by a 60-mile-wide crest that has a characteristic median cleft, or "rift valley". In this valley, depths of about 2000 and occasionally even 4000 fathoms occur. A seismic, or earthquake, belt closely follows the path of the rift.

It is not too hard to imagine deep-running subs using

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Copies of the map of the undersea environment in the North Atlantic are available at \$1 each. Special prices for bulk orders on request. Send order and remittance (no stamps, please) to Reprint Dept., SPACE/AERONAUTICS, 205 East 42nd Street, New York 17, N. Y.
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MEDITERRANEAN outflow at a depth of 1000 m.

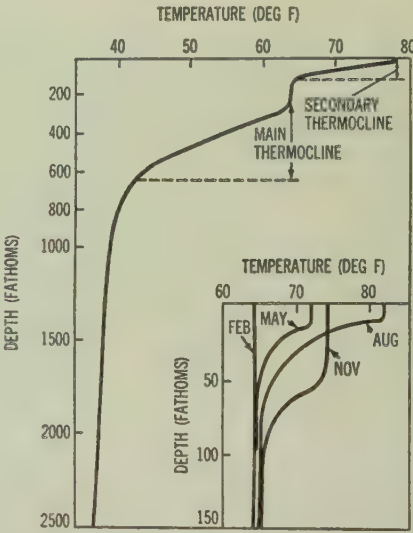


FIGURE 1: Temperature vs depth for a mid-latitude area of the North Atlantic in mid-summer and seasonal variations of the surface layer in the same area.

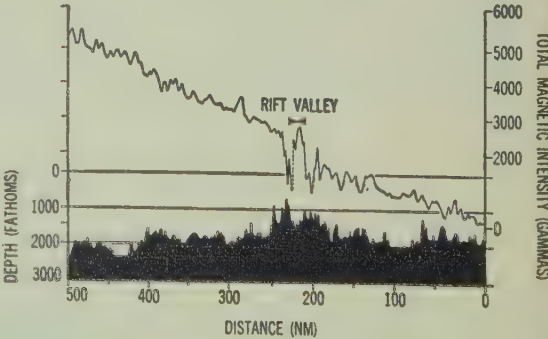
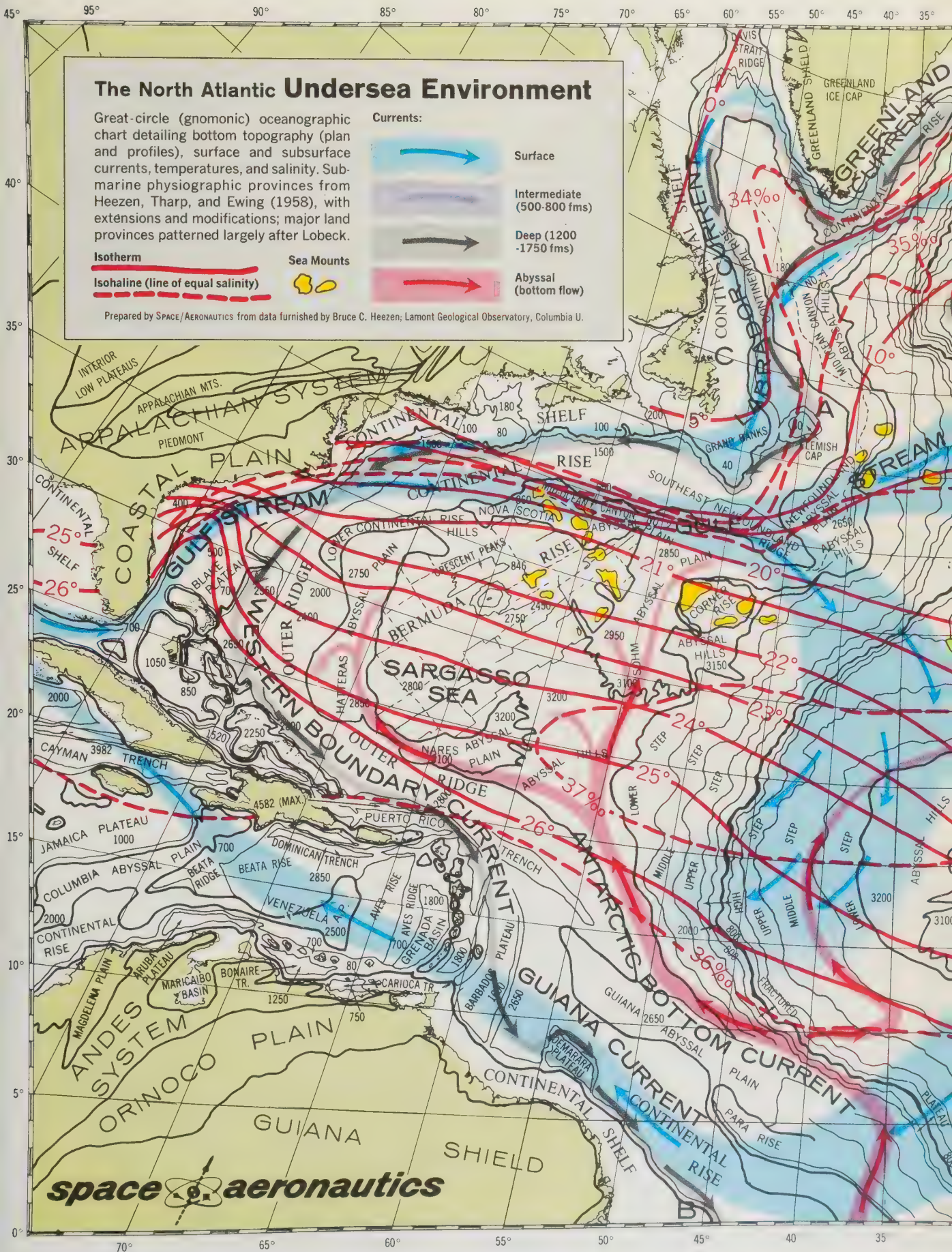


FIGURE 2: Profiles of total magnetic intensity and bottom topography across the Mid-Atlantic Ridge. Bottom soundings were made with a precision depth recorder; for the magnetic measurements, a flux-gate total-intensity magnetometer was used. The gamma values relate to an arbitrary zero.



- *Globigerina ooze* is sand composed of animal shells ranging from 100 to 200 microns. The most widespread sediment, it covers about 30-40 per cent of the total sediment area. Its surface density averages 1.3-1.7.

- *Diatom and radiolarian ooze* is a variation of red clay.

- *Red clay* is the second-largest sediment in area. Its surface density averages about 1.3, and it reflects the least distinct echo of all sediments.

The currents generally provide a good index of the dynamic character of the ocean environment. Subsurface currents, however, are generally analyzed and located by inference and theoretical extrapolation and from occasional measurements. In a number of cases, the theoretical locations of submerged currents—particularly those moving in a direction opposite to that of the surface currents—have been proved valid.

Such factors as oxygenation, temperature, and salinity determine the vertical cycling of the sea waters and the rhythmic pumping action that continually ventilates the huge ocean basins.

The speed of currents generally diminishes with depth, except in isolated cases in which gravity governs. For instance, the Gulf Stream's speed is 2-4 knots, the deep Western Boundary Current generally flows at about $\frac{1}{3}$ - $\frac{1}{2}$ knots and the Antarctic Bottom Current wanders along the abyssal plains at about $\frac{1}{8}$ - $\frac{1}{4}$ knots.

Currents rotate about the South Pole

The major marshaling point of the world's current circulation seems to be the Antarctic. For example, the West Wind Drift Current, unchecked by land obstacles, here is driven around at up to 6-7 knots by winds of unequalled force. Deep underwater currents also rotate about the south polar continent. Many major surface and deep currents are impelled into other ocean basin by this mass centrifugal action.

In addition to the winds, variations in barometric pressure and tidal influence govern the entire surface circulation scheme. Internal controlling factors are the earth's gravity field and changes in the specific gravity of the sea water with variations in temperature and salinity. Lesser factors are the Coriolis effect and the centrifugal force we have already noted.

Water in general has fairly well-known physical properties that are detailed in a number of general references.² Many of these properties depend on temperature and pressure, but in the case of sea water, salinity must also be considered.

Briefly, the main differences between salt and fresh water are:

- *Greater Specific Gravity*—A liter of sea water weighs about 1.025 kg, depending on temperature, salinity, and pressure. Variations in specific gravity with dilution or concentration are one of the ocean's most important characteristics.

- *Lower Freezing Point*—The limit in sea water is said to be about -2 deg C.

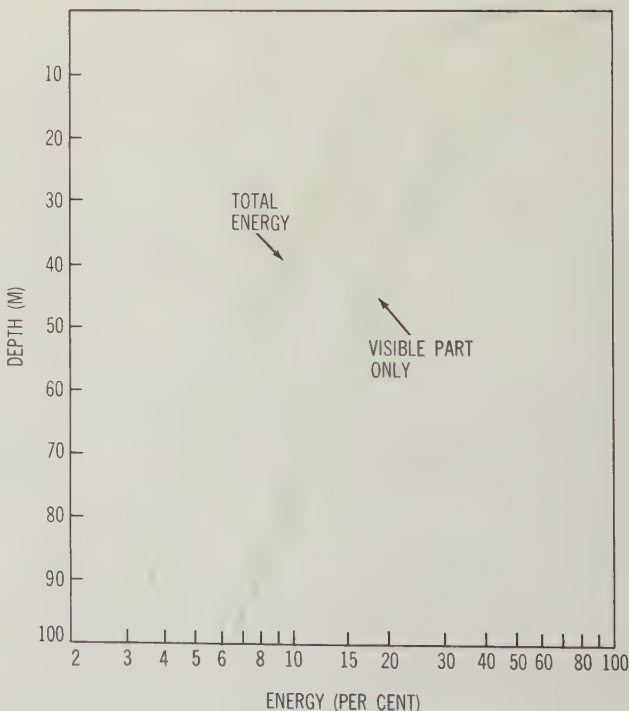
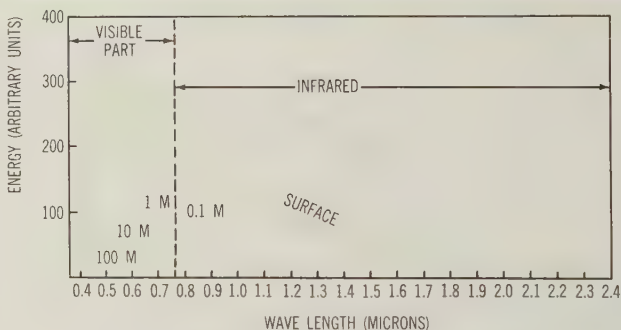
- *Lower maximum-specific-gravity temperature*—Fresh water reaches its maximum density at four degrees C, but when normal sea water cools, it contracts until it starts

to freeze. Readings of zero and less are common in the polar seas and along the ocean bottom. Oceanographers give temperatures in degrees C ± 1 deg with the latest instruments. Salinity is measured in grams per kilogram or parts per thousand; an accuracy of ± 0.02 is minimal. Pressure is given in atmospheres or in c-g-s units, one unit being equal to dyne/cm². One million dyne/cm² constitutes one bar.

The unit actually used in oceanographic measurement is the decibar, which equals 0.1 bar. It very nearly defines the pressure exerted per square centimeter by one meter of sea water. In other words, hydrostatic pressure in the ocean goes up by one decibar with every meter of depth.

In measuring ocean pressures, atmospheric pressure is always neglected and surface pressure is taken as zero. Present data show that ocean pressures range from zero at the surface to about 10,500 decibars in the deepest levels.

The density of ocean water is characterized by gen-



ENERGY SPECTRUM of the radiation from sun and sky (top) that penetrates the sea surface and the spectra in pure water at depths from 0.1 to 100 m. Bottom: Total and visible energy reaching various ocean depths.

(2) For instance, Sverdup et al, "The Oceans," Prentice Hall, New York ('42), or the International Critical Tables.

rally stable vertical stratification and horizontal differences caused by the effects of currents. Its general distribution is thus closely related to the nature of the currents; however, in every ocean area, water of a particular density will sink or rise to the depths at which that density normally occurs and then spread there. Because the density of the water depends on temperature and salinity, it is affected by any process that changes either of these variables.

Temperature and density (salinity) are of great importance in undersea warfare, especially because of their effects on acoustic propagation and velocity. Generally, there is far greater uniformity of temperature at sea than on land. In the tropics, surface temperatures average about 30 deg C with little variation. In polar regions, surface temperatures stay pretty close to zero. The average temperature throughout most of the oceans is about 17.5 deg C (from 19 deg C in the northern hemisphere to about 16 deg C in the southern).

As you go to lower depths, the temperatures generally decrease. The drop is small in the first 20-30 fathoms (the so-called secondary thermocline), because of the mixing action of waves and current. Then comes a fairly steep, progressively increasing drop as you descend to about 100 fathoms (the main thermocline). As you then go farther down through the deep-water layers, the drop becomes quite gradual again and ends uniformly at about -1 to +5 deg C (*Fig. 1*). The division between the main thermocline and the deep-water layers is generally put at about 600 fathoms.

The *Table* lists some of the major chemical constituents of sea water. Oceanographers stress that we still have

much to learn about the nature and interaction of the physical and chemical properties of their medium. A program is now underway to get samples of sea water from all over the world for detailed analysis.

Marine biology also is very important for undersea communications, detection, and navigation. Marine animals of innumerable species and sizes contribute to the general volume of noise that exists in the oceans. Whales, snapping shrimp, porpoises, and other denizens of the deep all add their peculiar grunts, crackling, and squeaks to the general din in which the sonarman or the torpedo homer must spot a single, elusive target. On the other hand, fish apparently have solved the problem of propulsion noise—they don't produce cavitation even while moving at great speed.

To both active and passive acoustic detectors, schools of fish, whales, porpoises, and other animals can sound exactly like a sub. Also, deep-scattering layers of phytoplankton give false bottom impressions and can be used by subs as protective cover.

Fish apparently have evolved extremely successful means for communicating underwater. This is inferred, Helen Hayes, of ONR's Biology Branch, told *SPACE/AERONAUTICS*, from the instantaneous response of all members of a school to some kind of command by one of them. The speed of response has led some to suspect that a form of electric impulse may be involved.

The well-known migratory habits of marine species are being studied in hopes of getting pointers on how to improve our own navigation techniques. It is theorized that the migrants in the ocean may be using topographical highlights as well as super odor-homing acuities. —End



FIGURE 3: World-wide distribution of ocean sediments.

State of the art: **detection and communications**

- Most sub detection still relies on sonar
- Electromagnetic "window" remains elusive
- Satellites may solve communications problems

by **James Holahan**

Electronics Editor

IN BOTH detection and communications undersea, some form of energy must be exchanged between two remote points. In both, the medium of transmission, sea water, poses the biggest problems.

Sea water is impervious to most known types of transmission and will only mildly support others. The undersea environment in general is characterized by unpredictable, sharp, and often sudden variations.

Sub "hunting" may be divided into three phases: (1) detection proper, in which you determine that there is an object in a certain large area that may be a sub; (2) localization, in which you estimate the space coordinates of the object; and (3) classification, in

FIGURE 1: An "electromagnetic window" in sea water is being sought by the Navy, but with only slim hopes of success. If it were found, it would

actually put subs out of business. These attenuation-vs-frequency plots were compiled by Naval Research Labs from the literature. The deepest

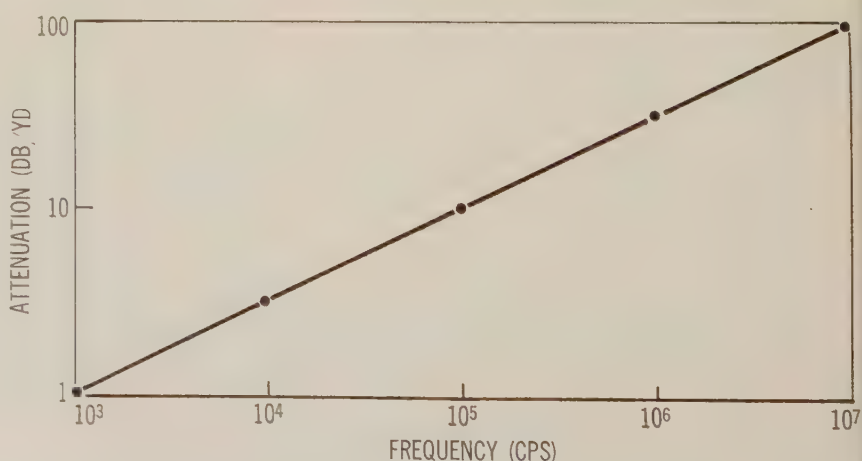
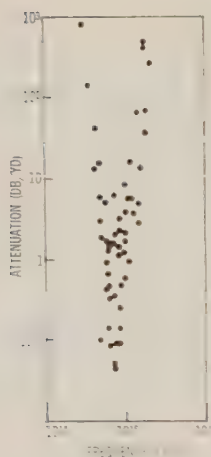
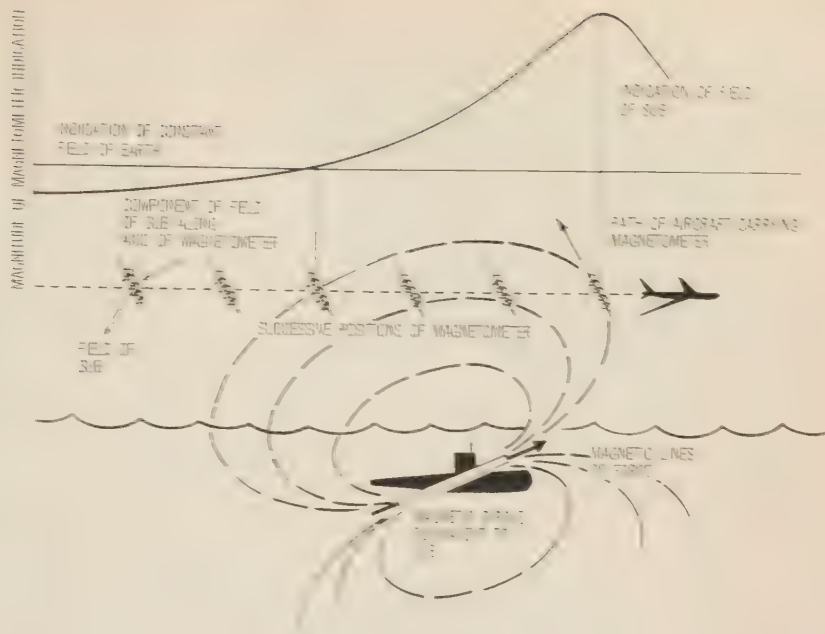


FIGURE 2: Magnetic-anomaly detector (MAD) is carried by Navy fixed and rotary wing aircraft. Used to classify targets, its present range is about 1000-1500 ft. The graph shows (1) how the orientation of the magnetometer's axis and the sub's heading determine the magnitude of the magnetometer indication and (2) how a magnetic dipole represents the magnetization of a sub.



which you estimate the statistical characteristics of the object. These three phases overlap a good deal and actually the same or nearly the same gear is often used for all of them. We'll therefore treat them together here and use the word "detection" broadly to cover all three.

Despite the well-known limitations of acoustic waves in water when applied to a range and angle determination, there appears to be nothing on the R&D horizon that could replace sonar for detection. For the last five years, the Navy has been working hard on the development of non-acoustic systems to replace it or at least supplement the acoustic ones. Yet the only widely

used non-acoustic device is the magnetic-anomaly detector (MAD). Some of the non-acoustic areas under study are:

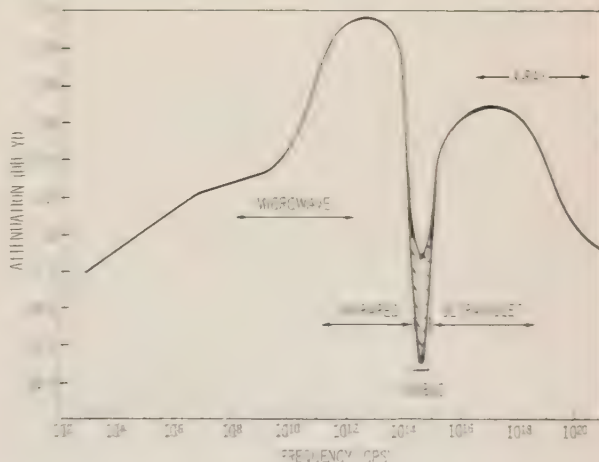
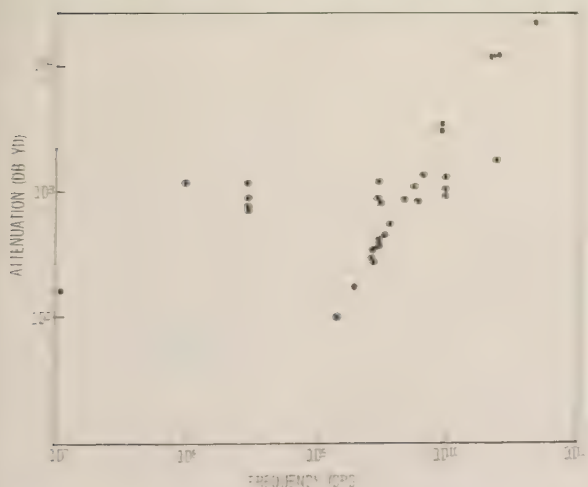
- **Magnetic**—The characteristics of the earth's magnetic field are the same in the ocean as in air. The MAD, the Navy's principal classifying device, is based on this fact (Fig. 2). Carried by anti-sub-warfare (ASW) fixed- and rotary-wing planes and by blimps, it senses changes in the earth's magnetic field that could be caused by an object with a large magnetic moment, like a sub.

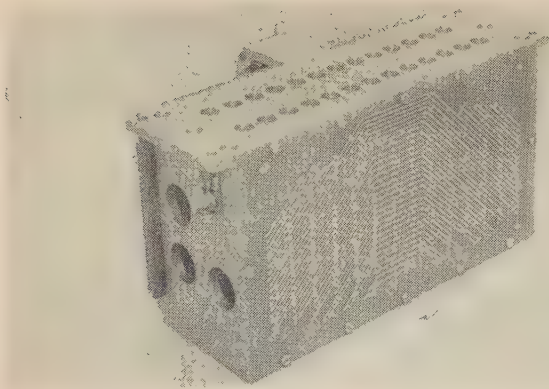
The sensing element is a magnetometer oriented

more on next page

"hole" appears in the green or the yellow-green portion of the visible spectrum. The graph at right summarizes the data of the other three

graphs. Its curve has been smoothed, however, and should not be taken as more than a visualization of the trend of available attenuation data.





ELECTRONIC scanning matrix is the heart of a transducer electroscan system designed by Bendix Pacific. It does electronically what is now done mechanically in most operational sonars.

parallel to the earth's field by a three-axis, servo-driven gimbal system. Current saturable-core magnetometers can spot an anomaly of 0.3γ , or 10^{-5} oersted, in the earth's field. BuWeps is looking into two nuclear precession magnetometers and another one that depends on the variable μ in ferrites. These units are believed to have sensitivities of 0.01γ and are about the size of a beer can.

The range of present MAD equipment is around 1000 ft. Dalmo Victor, one of the leading MAD gear designers, is studying dunked magnetometers in an effort to extend this range.

- *Electric*—Salt water is a fair conductor (about four ohms/m), and a sub, being made of metal, develops a charge through electrochemical action. If two electrodes with a potential difference between them are set up in water, current will flow, and the conductance of the path can be monitored. If a charged body, such as a sub, passes through this monitored area, a change

in conductance will be noted. The drawbacks of this technique are the many possibilities for false alarms, poor resolution, and short range (about 200-300 yd maximum).

- *Electromagnetic*—The discovery of an electromagnetic "window" in the sea, were it large and clear enough, would solve the detection problem so thoroughly that the sub would be out of business as a weapon. Judging from the results so far of the search for this window, the future of the sub is not in jeopardy.

As Figure 1 shows, the only "hole" in the spectrum is the one, 10 Å wide, in the green-to-yellow-green part of the optical region. Unfortunately, there aren't any high-intensity sources on this wavelength. Even if there were, their penetration would be limited. For example, sunlight (a rather powerful source), won't penetrate water more than 100 ft, and even in this case there is a high optical noise level.

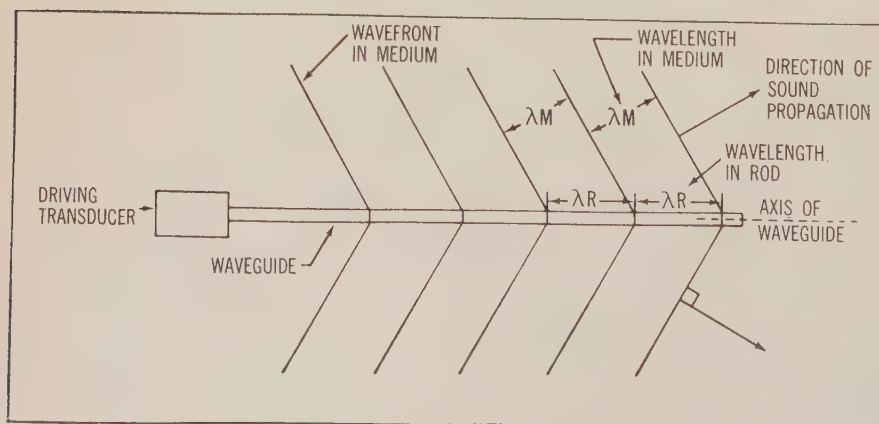
Because of the "skin effect," it is possible for radio waves to penetrate sea water. Their depth of travel is an inverse function of frequency. VLF and longer waves penetrate to some degree (Figs. 1 & 5) and possibly could be used to detect subs that are quite close to the surface or to a submerged antenna. VLF seems to be more useful for communications, however.

Cutwater now is almost dormant

In Project Cutwater, sponsored by the Office of Naval Research (ONR), many top electronics companies studied the possibility of detecting submerged subs by radio and radar. Hopes ran high for the project around this time last year, but today Cutwater is almost dormant.

Reportedly what set off Cutwater was an unclassified Japanese report that noted the field strength of radio waves diminishes on the sea surface in the vicinity of a submerged metallic object, like a sunken ship. The Japanese, it is believed, concluded that the metal had some absorption effect on the waves.

FIGURE 3: Sefar transducer operation (left) with velocity of sound waves greater in the rod than in the medium. Right: Typical directivity



pattern at 10 kc of a model that reportedly has an efficiency of over 60 per cent and handles over two kilowatts of power.

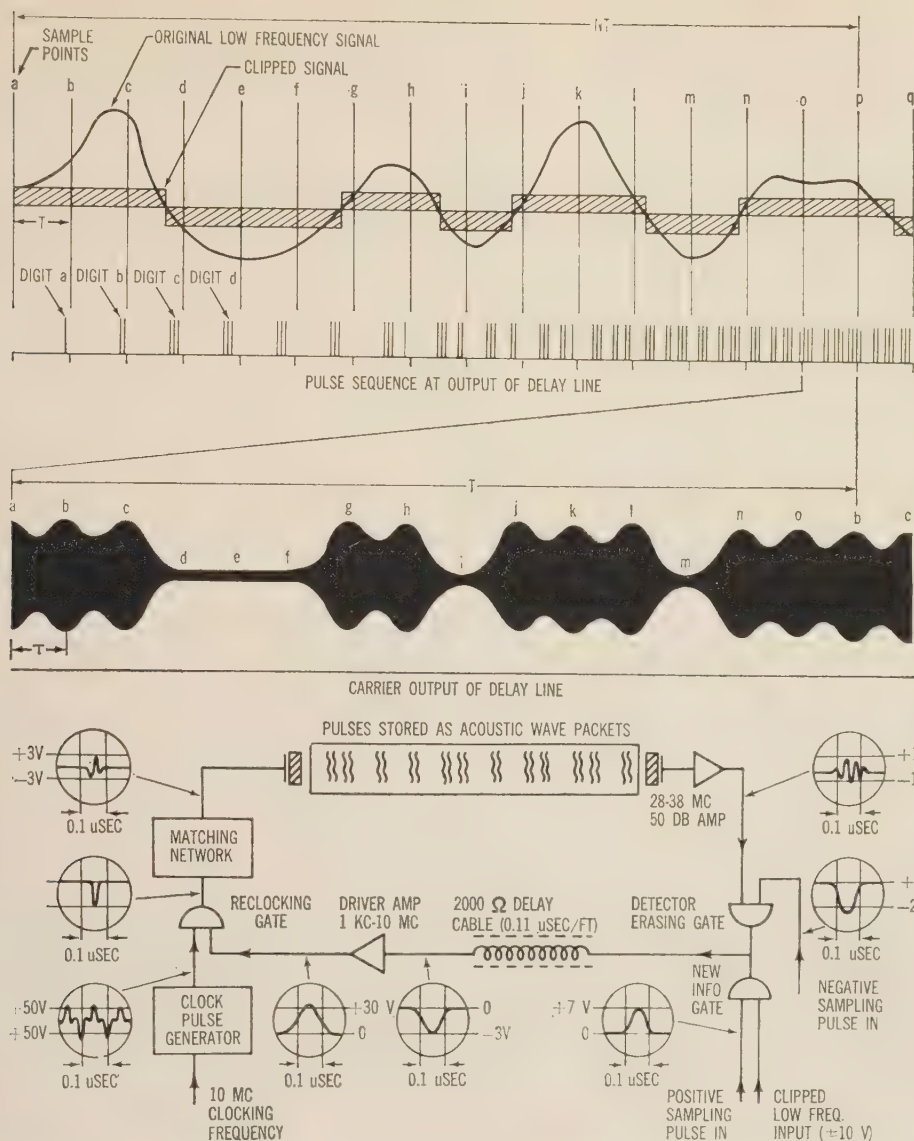


FIGURE 4: The Deltic polarity correlator is used in some of the Navy's more sophisticated sonars. A time-compression device, it makes it

possible to process signals without information loss. Top: Sampling process. Bottom: Recirculating memory, which is the heart of the system.

Some Cutwater researchers observed radar returns and propagation anomalies apparently produced by submerged subs. However, these observations could not be repeated with any regularity, and it proved impossible to spell under just what conditions they would occur. Nor was anyone able to determine beyond doubt that the observations had something to do with the presence of subs, though most Cutwater participants interviewed by SPACE/AERONAUTICS do believe that they were due to submarine-caused surface phenomena.

BuAer recently turned in a negative report to ONR on the feasibility of using these "phenomena" for detection. Nevertheless they are still being studied in some quarters.

Radar is by no means out of the picture as a sub-

hunting device. It is being studied for use in spotting the surface wave caused by a submerged sub. Some researchers believe that a sub causes a certain specular reflection on the surface that can be picked up to Q-band radar.

From the air, X-band radar can spot a surfaced snorkel (about the size of an oil drum) in all sea states, claims BuWeps. However, many submariners don't believe this.

- *Infrared*—In undersea detection, IR gear senses temperature differences in the surface water directly over or in the wake of a sub. IR sensors can detect a temperature difference of 0.01 deg F. The chief problems appear to be high seas and rain, heavy fog, and haze, all impenetrable to IR waves.

more on next page

• **Nuclear** — Nuclear subs theoretically could be spotted from either the radioisotopes or radiated particles they leave in their wake. The particles, however, are believed to be attenuated to undetectable levels by the water. Another nuclear effect that is under study is Cerenkov radiation, in which electrons (beta particles) traveling faster than light give off a distinct glow.

• **Molecular Energy Coupling**—Arma researchers believed molecular-energy coupling would yield non-electromagnetic propagation that would penetrate water to a considerable depth. It applies techniques now used in the study of solid-state films with hypersound (in the kilomegacycle region).

Other detection schemes that are under consideration are based on biological changes suffered by minuscule sea animals and plants or by chemicals in the wake of a sub; closed-circuit, low-light-level television; pressure-sensing; and gravitational anomalies. If any of these methods will work at all, it apparently would be only over short ranges.

Active and passive sonar is mounted on subs and surface ships and dunked and towed by aircraft. Under Project Artemis, sonar stations are being set up along the continental shelf to form a kind of underwater Dew Line.

Many of the oddities of acoustic waves in water (changes in propagation velocities, refraction, reflection, shadow zones, sound channels, reverberation, etc.) are well known; many others are still being discovered.*

* See J. W. Horton, "Fundamentals of Sonar," U. S. Naval Institute, Annapolis, Md., ('59).

The sonar designer needs high powers to overcome propagation losses (*Fig. 5*) and noise (ambient and returns from various scatters in the ocean). However, the amount of power he can put into the water is limited by cavitation to about 0.3 W per square centimeter of transducer area at the surface; this amount increases with depth as the square of the static pressure. Since high power means large transducers, we badly need new methods of exciting the water with high power sonic waves. Explosive, pneumatic and hydraulic sound sources are under development.

Since World War II three significant sonar trends have developed:

- In "*brute force*" designs, we have been aiming at low frequencies and high powers.

- *Signal processing* to get better S/N began five years ago and now is included in almost all new designs.

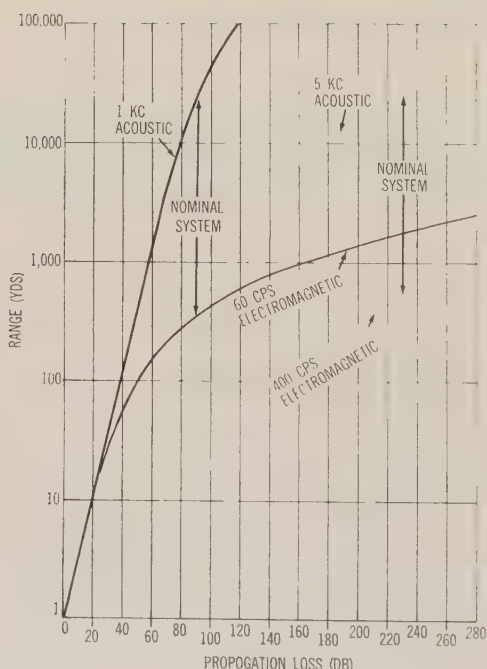
- *Data processing* is still in the embryonic stage. Present "brute force" systems operate in the low kilocycle range, using up to megawatts of electric power at the transducer input.

Three types of correlators in use

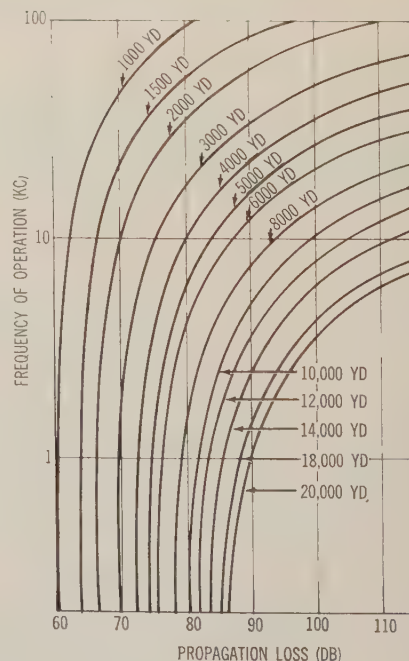
In signal processing, three types of correlators are used: (1) polarity coincidence, (2) ring modulator, and (3) multiplier. In the form of the Deltic correlator, the first type appears to be the most popular (*Fig. 4*).

The need for digital data processing has come more acute with the extension of sonar range through high power and lower frequencies. Doubling the range just about squares the number of returns from false targets.

FIGURE 5: Propagation loss (left) for one-way (black) and two-way transmission (color) of acoustic and electromagnetic energy in sea water. Nominal system shown for comparison



can overcome 100-db loss (assuming an arbitrarily assigned target source level). Right: Propagation loss vs frequency for a nominal operating sonar.



In these days of expensive weapons, we just can't afford to let go at whales with torpedoes and missiles, and so we have to process detection data to make reasonably sure of our targets. This undoubtedly will mean comparing returns with stored signatures of subs, whales, school of fish, etc., as well as the use of data from non-acoustic sources where available.

For the bulk of the processing today we depend on the sonarman. Many researchers suspect the trained sonar operator actually relies on extrasensory perception in picking out the true target among a scattering of false blips on the scope that look almost the same.

Transducer development is one of the most important phases of the sonar work. Barium titanate is used in most designs across the entire operating spectrum from a few to hundreds of kilocycles. Newer types of ceramics are being introduced that have higher coupling coefficients and less losses. However, they probably will not be used "across the board," because of their much higher cost.

A novel transducer is the Sefar, developed by Acoustica Associates. It is analogous to the highly directional end-fire antenna array. A long cylinder, it radiates sound into the water by sending out axially symmetrical waves traveling in the direction of the cylinder's axis (Fig. 3). A 10-kc model being tested by ONR reportedly has a directivity index of over 20 db, an efficiency of over 60 per cent, and a power handling capability of over two kilowatts.

The submerged sub can communicate with other subs and surface ships by sonar. Its problem is security—how to signal without giving away its position and revealing the contents of the message. We know that many imaginative security schemes are being tried—the rest is classified. It would seem feasible to mask signals in noise akin to the ambient ocean noise. There is a "secure" depth finder that uses binary signals enveloped by pseudo-noise, and the same technique undoubtedly can be applied to communications.

Sound channels, since they support acoustic waves with little spreading loss, make excellent paths for long range communications. However, they become "party lines" for anyone who drops in a hydrophone.

Bombs send out long range signals

Sofar bombs, explosive charges set to go off in the deep sound channel (600 fathoms), are used for long range signalling. Their explosive waves travel for thousands of miles. Another method of communications is sonobuoys, released from either subs or aircraft.

For direct communications with aircraft, shore stations and distant surface vessels, a sub normally relies on radio. The bulk of the service is in the 2-30-mc band. In using this band, the sub must have its antennas out of the water and must contend with the well-known propagation anomalies caused by the upper atmospheric layers.

For very long range, VLF is used. The Navy has a number of one-megawatt stations in the 10-20-kc range and one station of about 10 MW near Annapolis, Md. A second 10-MW VLF station is going up in Maine. Since VLF waves penetrate water to some extent, a sub can pick up VLF signals even with its antennas submerged.

Efficient VLF radiation from a sub would require an antenna about 1000 ft long and in series with a large tuning coil. Since a sub would have considerable trou-

ble carrying such gear, the VLF link is used only for one-way transmission. Low frequency antennas of more practical size are under development by BuShips, including one that floats to just below the surface.

As we've noted, penetration of water by radio waves, made possible by the "skin effect," is a function of frequency (Fig. 1). It is negligible except in the VLF spectrum. The attenuation-frequency curve is fairly linear in the lower part of the spectrum—about 1.1 db/ft at 10 kc and almost 20 db/ft at 1200 kc.

A relationship for skin-of-napier depth (at which the field strength is attenuated one napier, or 8.7 db, below its value at the surface of the water), was derived by Harold A. Wheeler, of Wheeler Labs (now a part of Hazeltine Electronics):

$$\text{skin depth} = (\frac{1}{2}\pi)(\lambda/30\sigma) m,$$

where λ is wavelength (in meters) of the wave in air and σ the conductivity of the water (in mhos/m). Regardless of its angle of arrival. Because of the high refractive index of water relative to air, the radio wave propagates into the water nearly vertically.

Signal reception at shallow depth

Naturally the maximum depth at which a sub would receive a useful signal would be a function of many parameters—field strength of the transmitted signal at the receiving antenna, antenna efficiency, receiver sensitivity, ambient and receiver noise, etc. Even an optimistic calculation shows that the maximum depth for useful 10-20-kc signals would be no more than roughly 50-100 ft. Looking into the problem of small sub-mounted VLF antennas, Wheeler found that the best type for omnidirectional reception is a pair of crossed horizontal dipoles (either electric or magnetic) coupled to the receiver in phase quadrature.

Very little has appeared in the literature on underwater electromagnetic radiation below one kilocycle. Yet this area apparently is being studied quite thoroughly. Stavid Engineering, Plainfield, N. J., is experimenting with "audio-electromagnetic waves" for undersea communications and remote control. Naturally the information rate would be quite low.

The velocity of these waves in sea water is a function of frequency and can be expressed as:

$$c = 4650f^{0.5} \text{ fps},$$

assuming the water has a resistivity of 20 ohms/cm. The attenuation due to sea water would vary according to:

$$\alpha = 0.0118f^{0.5} \text{ db/ft}.$$

For these extremely low frequencies, the antennas would have to be quite large. Even at one mile, a receiver would be effectively in the conduction field*—so you would not need a very efficient radiator. According to Stavid, the design approach actually would be entirely different from that used for radio antennas.

Communications satellites may be the solution to the sub's problem. Knowing the period and approximate path of a satellite, a sub could beam a small, directional VHF or UHF antenna into the right direction in space for transmission and reception. Of course, the antenna would have to penetrate the sea surface of the sea—possibly it would be raised from lower depths by a telescopic mast. Detection of the antenna by radar would be difficult at any time and wellnigh impossible in heavy seas.—End

* In other words, the electric energy would travel as electric current. At some point (at the end of the conduction field), it would begin to radiate as waves. The "antenna" might be a large electrode.

6

State of the art: **guidance and navigation**

- FBM subs to use inertial guidance
- Fairly low frequencies for radio systems
- Extensive signal processing is needed

by **Bernard Kovit**
Associate Electronics Editor

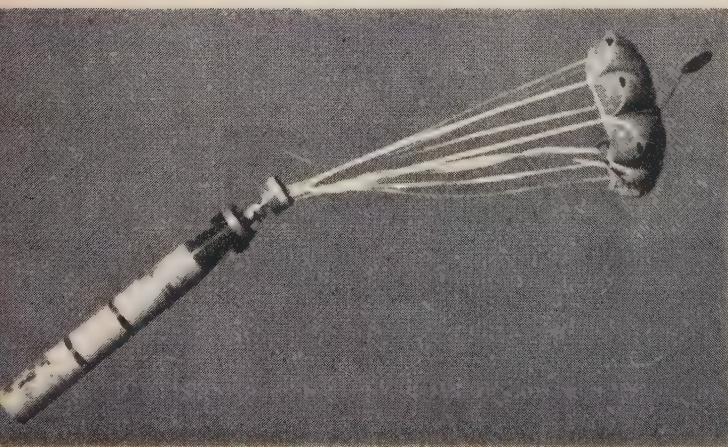


FIGURE 1: Air-launched Mark 44 torpedo is preset to spiral down from the surface of the sea and hunt the target by its noise.

UNDERSEA guidance and navigation must do two separate jobs:

- guide the missile-carrying submarine and precisely fix the missile launch position;
- guide anti-sub weapons.

In sub guidance, the trend is toward celestial-inertial systems integrated with fire and vehicle control through central computers. Inertial guidance is a natural for the Fleet Ballistic Missile (FBM) sub. It's self-contained, unjammable, and can operate in any latitude without magnetic references. Interestingly enough, it is quite a bit more reliable in a sub than, say, in an ICBM, for the sub's dynamics are relatively less severe. Both Autonetics and Sperry are building SINS (Shipboard Inertial Navigation System) equipment for the FBM subs.

Basically, the FBM sub's inertial system consists of a gyro-stabilized platform and a computer. Accelerometers mounted on the platform axes detect acceleration forces along these axes that are then singly and doubly integrated with respect to time to get the components of velocity and distance traveled from a known starting point. The computer converts the platform component outputs into continuous position and velocity data.

S. F. Eyestone, operation manager for inertial navigation at Autonetics, explains that his company's SINS was mechanized chiefly on the basis of Newton's Second Law of Motion. It follows the equation:

$$\ddot{\bar{A}} = d^2 r/dt^2 + g_{ma}.$$

The basic analytic models and resolved components of this equation determine the computer program for solving for position, velocity, and attitude (*Fig. 2*).

The most critical components of SINS are the platform gyros. Submerged operation lasting 2-3 months

Submarine Navigation Systems

System	Method	Range (miles)	Accuracy	Coverage
Loran C	measures time difference between pulses transmitted by two or more shore station groups	900 ¹	$\pm \frac{1}{2}$ mile at short range	good over N. Atlantic steamer routes, in Aleutians, China Sea, Gulf of St. Lawrence, around Great Britain
Decca	measures phase difference in CW transmission by two or more shore stations, would need extra high power transmitters.	line of sight	± 100 yd	good around Great Britain; spotty elsewhere
Consol	radio determination of great-circle bearing of single transmitting station; operates at 130-200 kc	1500	± 0.2 to ± 1 deg	eastern N. Atlantic (one station at Nantucket, R.I.)
Sofar	hyperbolic underwater sound location; shore stations figure distance to underwater explosion	4000 ²	± 4 miles	eastern Pacific and South Atlantic; experimental
Dectra	time-sharing single-frequency transmission from master and slave at each end of a fixed track; phase controlled to give hyperbolic pattern	2000	± 10 miles	North Atlantic
Omega	long range, very low frequency hyperbolic system using two or more transmitters	5000	± 2 miles	eastern Pacific; Hawaii-San Diego-Seattle
Draco				

(1) Ground wave; sky range up to 1400 miles with decreased accuracy (15 miles at maximum range). (2) Range limited by size of basin and topographic obstructions. (3) Details of this important long range electromagnetic system, built by Pickard & Burns, are classified

roduces a serious cumulative error due to mechanical gyro drift. Today, a sub can probably navigate with acceptable accuracy only for a few days. Even after such a brief period the accuracy may no longer be good enough for a Polaris launch.

The Sperry inertial platform uses a four-gimbal structure that is relatively large and heavy (its weight being used in attaining the inertial condition). Its gyros are out in the earth's field by mechanical rotation of their axes. Autonetics' platform is a lightweight, three-gimbal, analytical system that uses electronically torqued gyros. Latitude is given directly, and the horizontal components are derived in the external computer. The Sperry design gives a physical representation of both latitude and the local vertical, the components of latitude being derived internally.

Built with parallel characteristics

The two systems are built with parallel electric characteristics—a variety of external equipment can be hooked up to either system interchangeably. Three separate SINS units are reportedly used as the master source of inputs to the sub steering and armament control systems (with none of the three on standby).

In its SINS, Autonetics uses its Verdan computer, relatively well proven in several aeronautical applications. Verdan is basically a two-in-one digital design, with a general-purpose section and a DDA section sharing a rotating magnetic-disk memory. Sperry's Navdac (Navigation Data Assimilation Center) is an analog-digital complex with a magnetic-tape memory. Digital and analog circuits are used depending on specific requirements—e.g., analog when there is room for iteration, digital when error signals must be resolved.

The main goal of inertial researchers appears to be

better gyro performance. A wide variety of radically new designs is under study, notably electrostatic-spin and mercury-wheel gyros (Minneapolis-Honeywell), gimbal-less gyros (Ford Instrument), vibrating gyros (Westinghouse), nuclear-spin gyros (GPL and Maxson), and cryogenic gyros (Jet Propulsion Lab).

Some experts, however, claim we should concentrate on finding out whether a gyro could be made whose errors would conform to a pattern. The idea would then be to compensate automatically for any error that exceeds a particular magnitude.

Acoustic sub navigation depends on not only the art of echo sounding, which oceanographers have greatly perfected, but also on the availability of ocean bottom charts. At present, only the continental-shelf region has been adequately charted.

An acoustic Doppler technique is also a possibility. However, the anomalous effects of the ocean on acoustic energy pose difficult problems for it.

Non-acoustic navigation aids include celestial trackers, radio, measured-speed logs, and ocean-current recorders. The first two are by far the most widely used today.

Star-tracking features for scopes

The trend in celestial aids for inertially guided subs is toward a fully instrumented star-tracking periscope. Detroit Controls and Kollmorgen have come up with a stabilized one-ton scope (reportedly worth \$100,000) in which star angles are transmitted optically down the pipe and fed into a computer that applies a correction for sub motion and figures out the sub's position.

Kollsman Instrument proposes a somewhat different approach—a self-stabilized automatic star tracker built into the tip of the sub's periscope just above the regular

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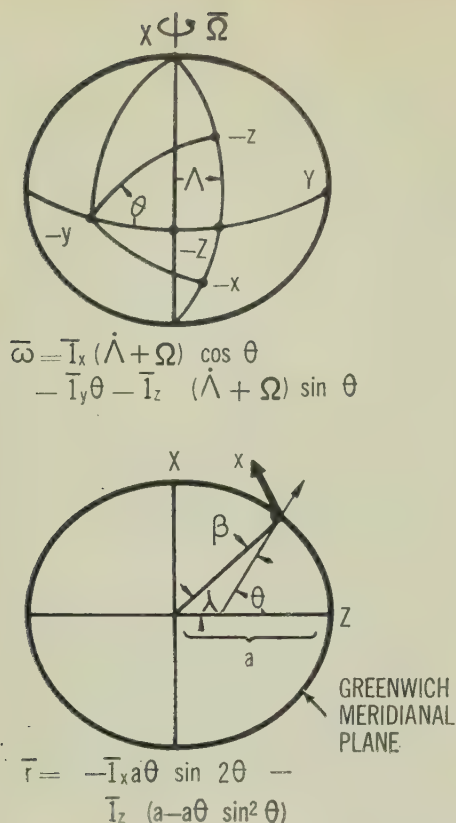


FIGURE 2: Derivation of the basic equations of inertial sub navigation is shown by the navigation coordinate systems used to define the angular velocity components (left) and by the definition of the position components (right), where X, Y , and Z are earth-fixed axes; x, y , and z , platform axes (z along the plumb-bob vertical); Λ is longitude; θ , geodetic latitude; a , equatorial radius; Ω , the earth's angular velocity vector; λ , geocentric latitude; r , position vector from the earth's center to the sub's present position; ω , the sub's angular velocity relative to inertial space; and β equals $\theta - \lambda$.

optics. To avoid major alignment problems, star angles would be transmitted electrically down the tube to a control computer.

For inexpensive conversion of any old sub periscope to the shooting of star fixes from a submerged sub Sperry offers its Scar (Submarine Celestial Altitude Recorder). It does an automatic celestial altitude computation with the aid of a high precision timer and standard navigation charts.

The Table lists some available or potentially usable navigation systems. It's quite clear that any usable radio system would have to operate at fairly low frequencies to overcome the attenuation and refraction losses that occur when electromagnetic energy penetrates even the surface of the sea. (A 50-kc signal suffers a drop of about 2.5 db/ft in the first two meters).

In the realm of completely secure nav aids, such as gravity or magnetic-field detection correlated with detailed bottom-topography charts, basically useful instruments and techniques exist but we have to wait for a build-up of oceanographic data. Also, though generally conceded to be feasible, these methods have their drawbacks. Perhaps the most severe limitation on mag-

netic-intensity navigation is the constant fluctuation of the earth's magnetic field. To overcome it, researchers are studying free- and even nuclear-precession magnetometers.

Underwater gravimeters, which are in development look promising for precision navigation. Experts point out that gravity measurements give us a means of computing the deflection of the vertical and of linking the geodetic networks of the continents.

Acoustic beacon transponders set up on the ocean bottom and coded to respond only to selected interrogations (IFF) are still another possibility for deep-water navigation. Oceanographers have used acoustic beacons to mark fixed positions at sea and claim to have gotten fixes accurate to within 100 ft. Present batteries would give such intermittently operated navigation beacons an operating life of at least 2-3 years.

Undersea weapon guidance is mainly a matter of wire-control for torpedoes and preprogramed control for free-running torpedoes and special types of ordnance that use airborne phases. With preprogramed control, pulse-sonar corrections might be used after the weapon has left the sub. In either case, success depends almost wholly on the accurate functioning of the sub-mounted fire control.

Automatically sequenced fire control

The problems of detection and target classification caused by the shortcomings of sonar generally have forced us to use extensive signal processing, notably autocorrelation, as a link between the detection gear and the fire control system (FCS). The latter must analyze the target information, determine the target's motion, and predict future target position. The trend is to make fire control a series of automatic sequences.

An example of conventional automatic target analysis is the analyzer-tracker in a fire control system designed by Arma. One of the techniques it uses is the "end point" method, which defines target motion by a straight line connecting the first and last target positions observed by active acoustic means (Fig. 3).

Components of target motion relative to the first bearing are derived from:

$a = R_i - (R_i \cos B_i - B_i) + Ma; b = R_i \sin (B_i - B_1) + Ma$
The computed target velocity vector is then automatically applied to a tracker that continuously figures target position on the basis of own and target's course and speed and target's initial range (R_i) and bearing (B_i). In simplified form, the equations for present range and bearing are:

$$R = R_i + \int R dt; B = B_i + \int R B dt.$$

Reliability is the reason for the Navy's apparent heavy emphasis on wire guidance for torpedoes. The present state of the art is represented by the lightweight Mark 39 (Vitro Labs) and 44 (Westinghouse-Ordnance). According to Vitro engineers, it's now possible to wireguide a torpedo all the way to the target.

In wire guidance, a thin (usually single-conductor) strand of wire is paid out by the torpedo as it moves away from the launching sub. The sub's FCS transmits steering signals over the wire to guide the torpedo to the vicinity of the target. Sea water forms the return

path. Design objectives are to extend range and to get more signal into and back from the weapon. A multi-conductor link is one possibility.

According to J. H. Beggs, manager of Westinghouse-Ordnance, nearly all wire-guided torpedoes today carry both passive and active acoustic homers. Active homing frees the torpedo from relying solely on target-generated noise and also defeats most anti-torpedo counter-measures.

A recent development is the Astor torpedo, which will have greater range, speed, maneuverability, and warhead power. Should this torpedo have an airborne midcourse phase, then wire guidance may be used to solve control-accuracy problems during the underwater boost phase. This elongated weapon is not the cheap, expendable item the lightweight torpedoes are. Its performance requirements are derived primarily from the defensive needs of the FBM subs, which must battle with the enemy's nuclear killer subs.

The effective range of wire guidance is probably 3-5 miles. The trick in laying so much wire is to avoid tension, snarls and kinks that might break it, and coils whose inductance could produce phase and frequency distortions in the electric signal. The wire spool could be loaded so that the torpedo's pull would release turns of wire with hardly any drag. This design would correspond to the spinning reel used in fishing, only with the lure anchored and the rod and reel cast out.

For free-running torpedoes and hybrid missiles, the main design objective is to build more self-guidance and homing capabilities into the weapon itself. Today these weapons are almost completely dependent on the sub's FCS, which loads up their angle solvers, course and depth keepers, and attack patterns with operational programs just before launch.

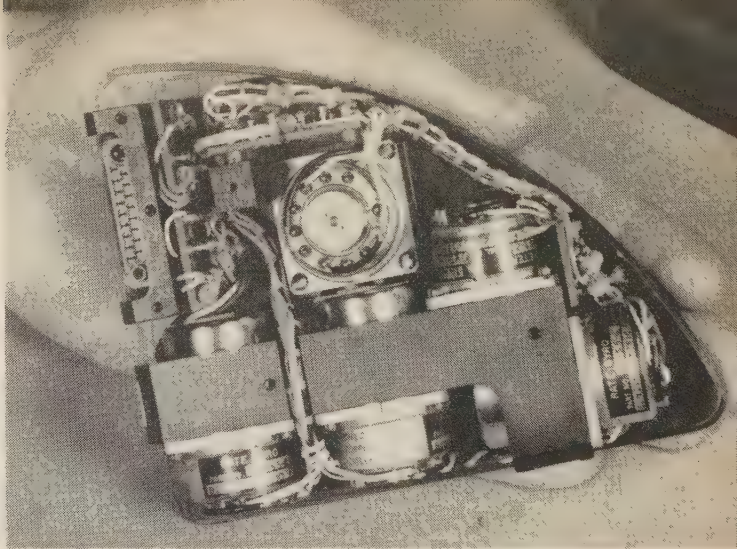
The need for a cheap and versatile weapon that can be air-dropped resulted in the small Mark 43 acoustic-homing torpedo, built by GE-Pittsfield. As this torpedo leaves the aircraft, a braking chute pops open and controls the descent to the surface (Fig. 1). At the surface, the chute is cast off, the weapon descends in wide spirals to a preprogrammed depth, and acoustically homes in on the target. Actually it can go off on a homing run at any point during the descent (search).

The need for speed in a small, easily delivered package will perhaps be met in the next generation of torpedoes. A prime example is the solid rocket Mark 46, being brought to the prototype stage by Aerojet-General and Bendix-Pacific. Bendix's guidance and control package reportedly sets new standards of intelligence and maneuverability, though it takes up only half as much space as do conventional designs.

Still troubled by sonar deficiencies

Despite the doubling of speed in the latest torpedo designs and their capabilities, we still do not have any undersea weapon that can reliably track a target at even moderately obtuse angles through layers of varying temperature degree of reliability. The trouble, of course, is always the same—the deficiencies of sonar.

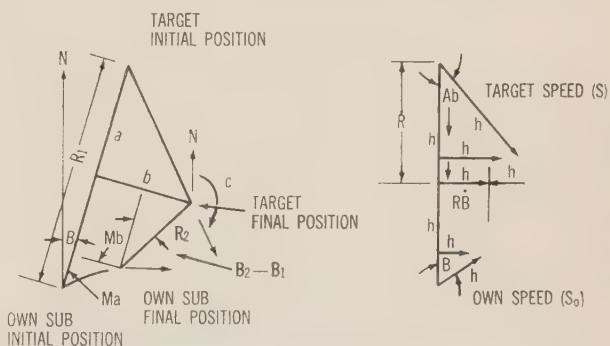
The Asroc and Subroc missiles will, it's hoped, get around this problem by faster delivery of more potent warheads. Asroc, under development at Minneapolis-Honeywell, has roughly a 10-mile range. In the water, it will use acoustic and non-acoustic homing.



PIE-SHAPED gyro and accelerometer package supplies stable reference data to the autopilot in the rocket-powered, self-guided Mark 46 torpedo. The modular package, designed by Fairchild Controls, uses three sub-miniature floated rate gyros and two floated pendulous accelerometers. The complete Mark 46 guidance and control system, for which Bendix-Pacific is the prime, was modularized and miniaturized to fit the advanced 12-in.-diameter torpedo.

Subroc, for which Goodyear is the prime contractor, will be launched from subs. A rocket booster will take it up out of the water, preprogrammed with long range target-position impact data. This booster will drop away, leaving the warhead to continue toward the impact region. After impact on the surface above the region in which a target was originally detected, Subroc acts as a nuclear depth charge.—End

FIGURE 3: End-point target analysis (left) and position-keeping method (right).

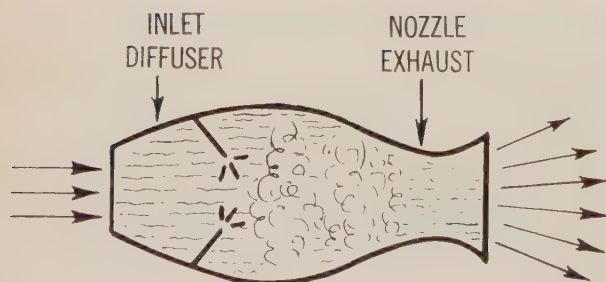


State of the art: **propulsion**

- Thermoelectric systems can fill dual role
- Fuel cells look most practical right now
- Jet thrust systems are being studied

by **Victor de Biasi**

Associate Editor & Project Leader

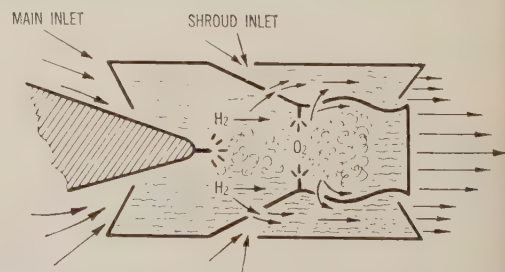


UNDERWATER RAMJET can be energized by water-reactant or solid fuel burned at diffuser end of entrance duct. Resulting flow is exhausted as mixture of water and steam. Momentum and temperature added to the steam and water jet are seen as thrust. Aerojet announced the first such engine seven years ago.

WHEN YOU COUNT them up, there are more schemes for underwater propulsion than for atmospheric or space propulsion. Practically every airbooster, jet and rocket design arrangement has an underwater counterpart—with the important difference that, in water, weight is not the critical problem it is in air.

As might be expected, you find the closest similarities to aerospace designs in the powerplants for torpedoes and hybrid air-water missiles and the greatest differences in submarine powerplant. But for sub propulsion, too, many of the more advanced paper studies make use of aircraft and space vehicle concepts.

What is the Navy looking for in the way of better underwater propulsion systems? You can define two general fields of study: propulsion systems for manned and unmanned submarines and propulsion systems for missiles with powered underwater trajectories. Current projects are known to cover:



IN TWO-STAGE RAMJET, water reactant or hydrogen-bearing fuel is fed into water to burn and also releases hydrogen. Ram pressure drives the mixture to the throat of the second stage, where an oxidizer is injected. Thrust is augmented by temperature and velocity increase in cooling flow through the afterbody ejector shroud.

- propellant-powered turbines and reciprocating engines and direct-coupled turbine drives;
- advanced energy sources—fuel cells, thermoelectric generators, thermionic converters, cryogenic propellants, and thermonuclear devices;
- jet thrust engines—solid and liquid propellant rockets, ramjets, pulsejets, turbojets, turbopumps, and magnetomotive pumpjets.

The aim of most of the work on thermomechanical systems is to fill the gap between the nuclear-powered submarine and its snorkeling predecessor with a relatively inexpensive non-air-breathing propulsion system. Hydrogen-peroxide-powered reciprocating engines and an advanced version of the Stirling-cycle engine are two of the possibilities under study.

Designers are also thinking of using conventional electric motor drives powered by unconventional energy sources. Three of the more important designs under study are thermoelectric generators and thermionic converters (both of which need a reactor heat source) and fuel cells. One big advantage of a thermoelectric system is that it can be used both for refrigeration and to generate electric power. This double role could be especially important in subs, whose blowers and motors are said to be among the worst noise makers when the sub is moving slowly or stopped.

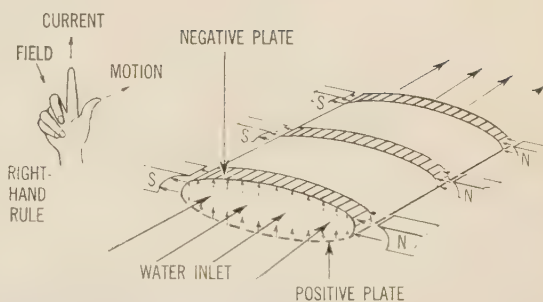
Right now efficiencies are not too high. But, according to a report by Paul H. Egli, of the Naval Research Lab, conservative estimates are that, with a reasonable amount of development, we could get overall efficiencies of about 20 per cent. More optimistic claims mention 35 per cent. It is believed that Westinghouse has built and is testing a five-kilowatt thermoelectric generator that may be followed by a much higher rated system.

Thermionic converters, which are still in an earlier development stage, also have interesting possibilities. Present efficiencies are low—around four per cent for

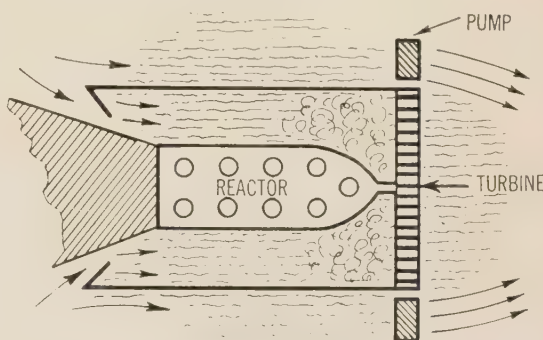
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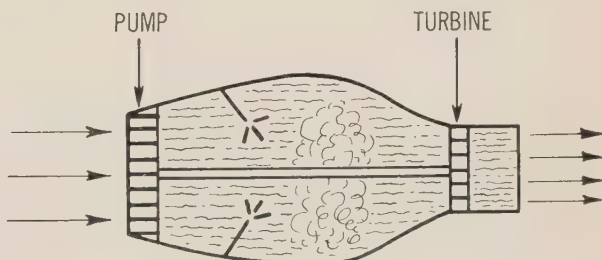
ELECTRIC-SPARK PULSEJET could use the shock wave created by an underwater spark to expel water from the open end of a rocket nozzle. Flapper valves open as the shock front passes to admit new charges of water. The new explosion then closes the valves as the wave front moves towards the nozzle.



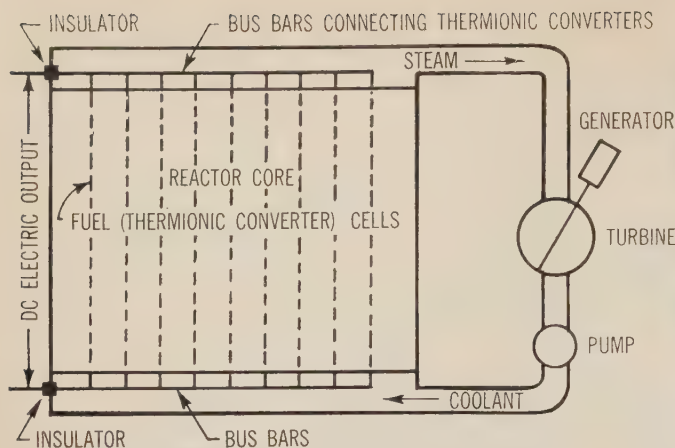
MAGNETOMOTIVE PUMPJET has no moving parts. Current flows from the positive to the negative side of the thrust duct, with the salt water as the conductor. In the presence of a magnetic field a force is exerted on the conductor to make it move (according to the right-hand rule).



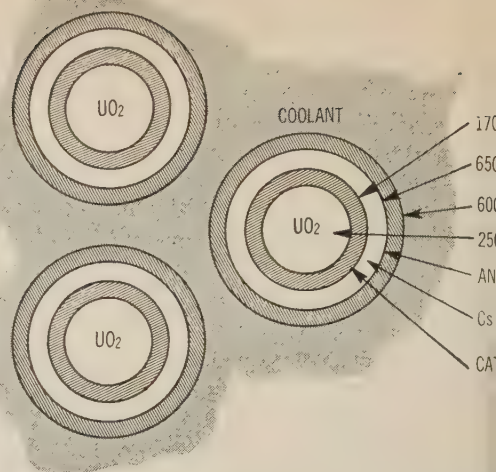
NUCLEAR TURBOPUMP REACTOR could be used to flash water to steam and drive a turbine. Free-stream blades on the turbine act as an impeller to pump water. The thrust is a combination of the steam and water passing through the turbine and the momentum exchange across the impeller.



UNDERWATER TURBOJET can use an exit turbine to drive an inlet pump to get good chamber pressure (instead of relying on ram pressure). The turbine could run on bypass steam instead of main flow. The energy release would be generated by a water reactant or a fuel. Several other designs are possible.



THERMIONIC CONVERTERS, still in the early development stage, might be used with atomic reactors to generate electricity. A sub could use conventional turbines and generators for full power when noise is not critical. For silent operation, the turbine would be turned off and the thermoelectric generator used instead. Present thermionic-converter efficiencies are still well under 10 per cent.



By dint of an extensive materials development program they could be increased to almost 30 per cent for vacuum types and ultimately to 40 per cent for filled types, it is estimated. Thermionic converters can be built around nuclear fuel cells as shown here schematically and in cross-section. Each fuel cell is also a thermionic converter cell.

practical designs, with a power density of about 0.25 W/cm². Volney C. Wilson at GE's Research Lab believes that, with a reasonable amount of R&D, we could reach power densities of 30 W/cm² at 30 per cent efficiency.

Wilson has shown that gas-filled thermionic converters could be built right into a submarine's nuclear reactor. The nuclear fuel elements would have to have a double-walled jacket containing cesium vapor. The inner wall would serve as the cathode and be heated by fission reactions in the fuel. The outer wall would be the anode and be cooled by conventional coolant.

Provided the reactor coolant pumps don't set up a racket, the thermionic converter design makes for a quiet propulsion system. For full power you would use the complete system with turbines and generators. For quiet maneuvering, you would use only the thermionic-conversion part of the system and turn off the generators.

Several companies recently submitted fuel cell proposals for powering a sub "smaller than existing nuclear submarines." A distinct advantage of the fuel cell system is that it conserves energy. It is a demand-type system that draws upon its gas supply only enough to meet load conditions. Since the fuel reacts automatically to adjust to varying load conditions, the control problem of the driven electric motor is also simplified. For normal missions (on which full power is seldom used) a fuel cell system could be expected to allow up to 30 days of submerged operation.

According to GE's Aircraft Accessory Turbine Department, which is working on the development of fuel cell systems for sub propulsion, the ion-membrane fuel cell potentially has the highest efficiency of any low temperature conversion system. GE estimates its complete system would weigh 148 tons and take up 9600 cu ft.

With more development work, the GE system probably be reduced to 114 tons and 8200 cu ft within five years, it's claimed. Heavier systems could be designed to operate off fuel oil, ammonia, or solid borohydride instead of stored hydrogen. Air could be used instead of oxygen.

Lots of theoretical and experimental work is also being done on jet thrust engines, particularly by Aerojet General, which seven years ago came out with the operating underwater ramjet powered by a solid fuel. This design has been tested at speeds of "over 200 knots" and probably can actually reach speeds close to 200 knots.

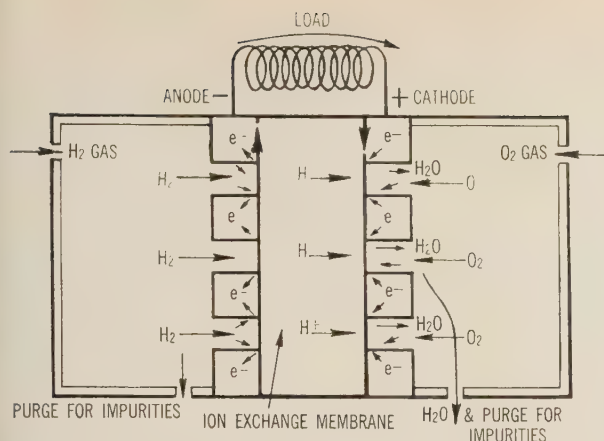
The underwater ramjet takes in water at ram pressure, flashes it to steam with a solid-fuel flame (at high pressure), and compresses and discharges it as a jet. A fixed intake is used for fixed thrust curves and a variable intake for variable curves. By regulating the flow intake, you automatically regulate fuel consumption and speed.

Must be brought up to speed first

Underwater ramjets (like their airborne counterparts) must be brought up to speed before operation. C. A. Gongwer at Aerojet told SPACE/AERONAUTICS that they can use augmentation schemes to produce 30-40 per cent more thrust at the start. However, this initial boost is lost as soon as you get underway.

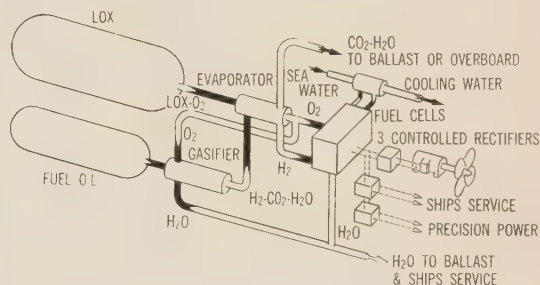
An underwater ramjet can be energized by a reactant (such as sodium or potassium) or by a fuel burned at the diffuser end of the entrance. The resultant flow is then exhausted as a mixture of water and steam. Any momentum or temperature change imparted to the steam and water is seen as thrust.

It might even prove efficient to have larger



FUEL CELL with an ion exchange membrane may prove ideal as an energy source to fill the gap between battery and nuclear power for subs. It would operate off a static supply of oxygen (or air) and hydrogen to generate electricity. The reactions would be $2\text{H}_2 \rightarrow 4\text{H}^+ + 4\text{e}^-$ at the anode, $4\text{e}^- + 4\text{H}^+ + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$ at the cathode, and $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$ overall.

FUEL CELL SYSTEM proposed by GE for a sub "smaller than existing nuclear submarines." Today, the complete installation would weigh 148 tons and have a volume of 9600 cu ft. In another five years, this could probably be reduced to 114 tons and 8200 cu ft. The heavier system could be designed to operate off fuel oil, ammonia, or sodium borohydride fuels instead of hydrogen.



stage ramjets in which a water reactant or a hydrogen-bearing fuel is fed into the water to burn and release hydrogen, too. In the second stage, the hydrogen-rich mixture of steam, water, and gas is mixed with an oxidizer to complete the cycle. Some thrust augmentation can be gained from a cooling flow of water ducted through an afterbody ejector shroud. The extra thrust comes from the temperature and velocity increase of the coolant.

In general, gas-driven ejectors are not too efficient. The energy stored in the gas as velocity is pretty well lost when the gas hits the water. But the scheme is still worth analyzing.

Water reactants actually are not being considered except for experimentation. They are much too dangerous to handle, store, and use under operational conditions. Other propellant combinations—many of which carry their own oxidant—have proved much better.

The simplest of all underwater jet engines is the solid propellant rocket. Propulsive efficiency is low, because speeds are much lower underwater than in air or space. However, the rocket has the advantage of a high thrust-to-frontal-area ratio and its operation is affected relatively little by great depths. Liquid propellant rockets can also be used, but high chamber pressures are needed for them at depth.

An electric-spark pulsejet might be designed to use the shock wave created by an underwater spark to expel water from the open end of a rocket nozzle. Flapper valves in the body would open as the shock front passes to admit new charges of water in readiness for the next cycle. The spark "explosion" would close the valves to keep the flow channeled toward the exit nozzle. A series of slowly charged condensers could be discharged sequentially at a controlled rate for optimum pulsing.

Several variations of the underwater turbojet are

possible. Once again a water reactant or a fuel is used to generate the energy release. A coupling off the exit turbine can be used to drive an inlet pump to get good chamber pressures (instead of relying on ram pressure). In a design of this type, the turbine can be driven by bypass steam rather than by the main flow.

A small nuclear reactor might be used to flash water to steam and drive a turbofan or turbopump. The free-stream blades extending beyond the turbine blades act as an impeller to draw water past the blades. The resultant thrust is created by a combination of the steam-water flow through the turbine and the momentum exchange produced across the impeller. (A water reactant or a liquid fuel could be used in place of the reactor.)

The most exotic of all designs would be a magnetomotive pumpjet with no moving parts. Current is made to flow through the salt water conductor from the positive to negative side of the thrust duct. In the presence of a magnetic field, a force is exerted on the conductor (water) to make it move (according to the right-hand rule).

Unfortunately, salt water is not quite conductive enough to make it a good coupling medium. Injecting an additive into the water to improve conductivity might do the trick but you would have to reclaim the additive to make this solution worth while. Voltage from a single power supply might also be sequentially peaked over a series of bands to move small "end plates" of conducting water with non-conducting water trapped in between.

With many of these systems it may be possible to combine the location and types of intakes and exit nozzles to reduce drag and suppress cavitation. How much you can gain will probably depend to a large extent on how effectively you reduce the internal friction losses of your systems.—End

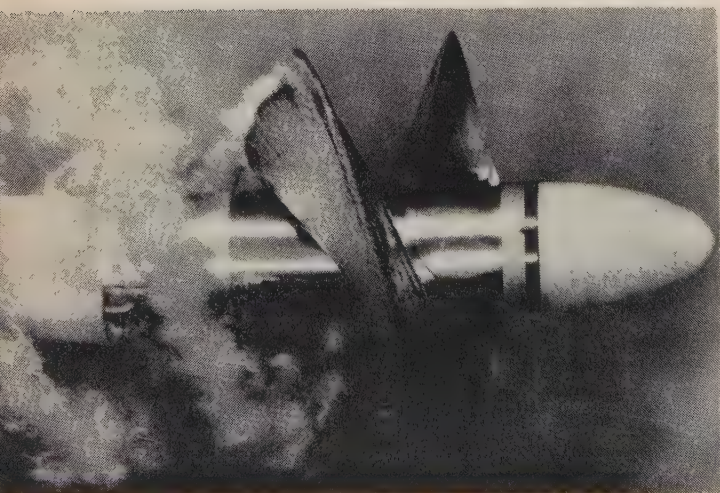
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State of the art:

Hydrodynamics, structures, materials

- Designers no longer “freeze” ocean surface
- Higher speeds through nuclear power
- Detail design is extremely critical

by **Irwin Stambler**, Associate Editor

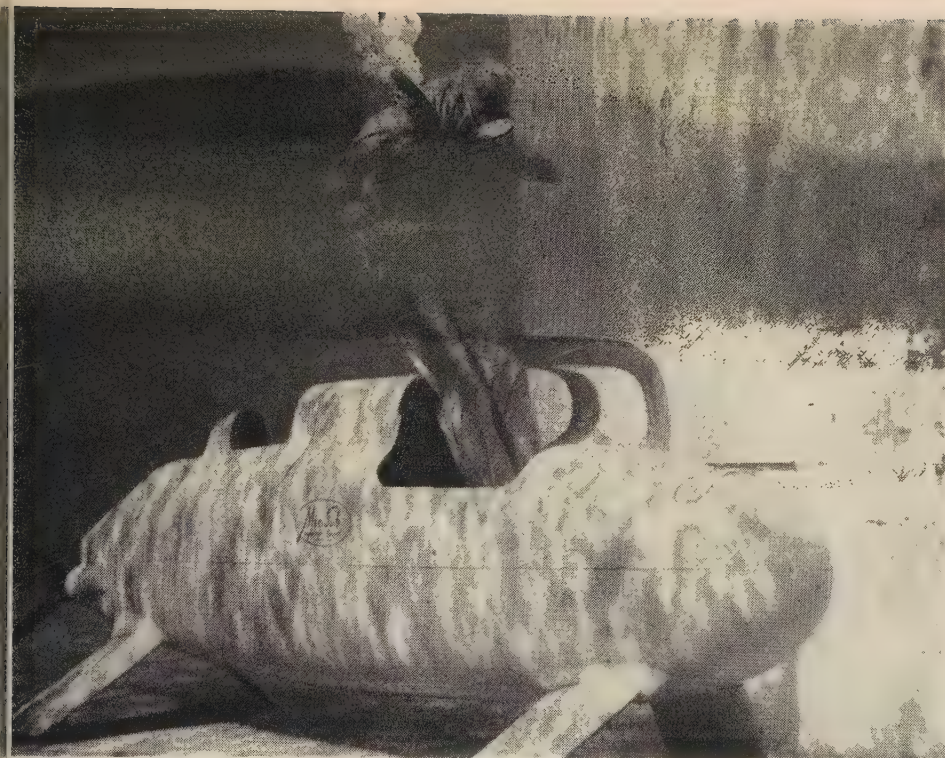


THE AIM of all seacraft development work today is to make it as relatively easy to design for motion through water as it is to design for motion through air. This is no small task, seeing that a great deal of scientific effort as well as financial backing has been devoted to aerodynamic progress in recent decades, while hydrodynamics has been almost completely neglected for close to 50 years.

Two major developments make it seem likely that we are on the threshold of a new era of seacraft design. One is, of course, the growing importance of anti-submarine warfare (ASW) to the security of the nation. The other is not so obvious: major aerospace advances in both theory and hardware promise to lead to equally major advances in many areas of seacraft design. Capt. R. B. Laning, former commander of the nuclear sub *Seawolf*, summed up this trend when he recently stated that, “ASW submarines will, in my opinion, look more and more like supersonic aircraft designs.”

One of the major problems in achieving the breakthrough the Navy has said is necessary in undersea warfare is that first we must gain a much better basic understanding of all phases of hydrodynamic theory. In many ways, it's been pointed out, we know more about the surface of the moon than about hydrodynamic and oceanographic theory.

SUPERCAVITATING propellers, one of the most recent hydrodynamic developments, turn cavitation effects from a disadvantage into an advantage. Their flanges, which have squared ends instead of the conventional tapered ones, are expected to lead to 50-knot speeds.



AERODYNAMIC FINS and faired surfaces of the Aerojet-General Minisub show the influence of aviation design on underwater craft. Moving at speeds of up to three mph, the vehicle has a propeller driven by pedals or a one-horse-power motor. It could be used for underwater exploration, demolition missions, etc.

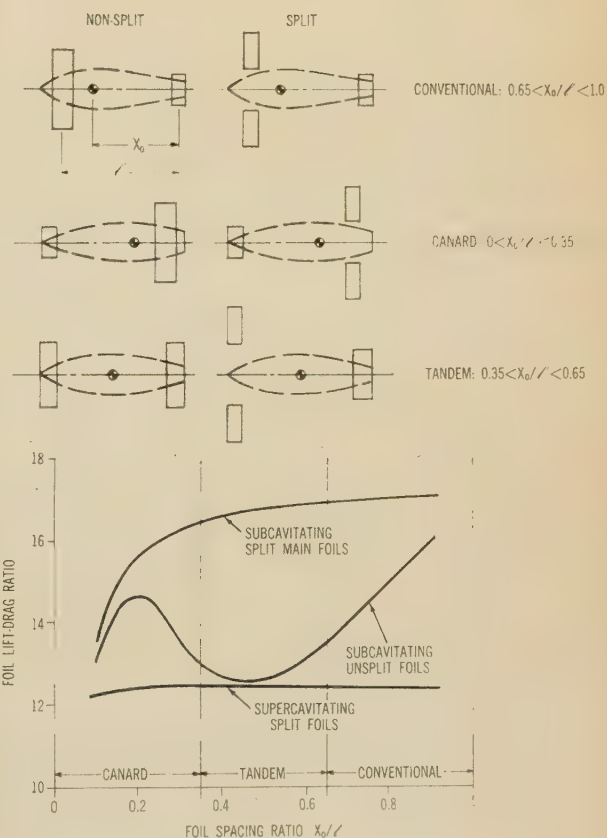
The first steps are finally being taken to give us a better understanding of the medium in which the sea-craft designer must work. In the design of surface ships, for instance, the traditional approach has been to "freeze" the surface of the sea by assuming a static wave and throwing in healthy factors of safety. Today, the application of computer methods like those used in aero-space technology, together with Bell Labs' sound techniques, possible to express any given sea as a series of regular seas of given period and direction. Studies are underway of the response of a ship to various stimuli, and work is being done on methods of predicting the types of seas that will follow given types of weather.

Designers aim for more efficiency

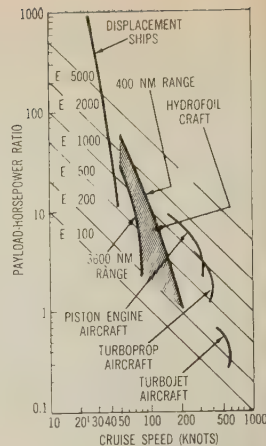
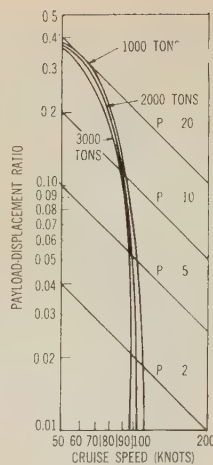
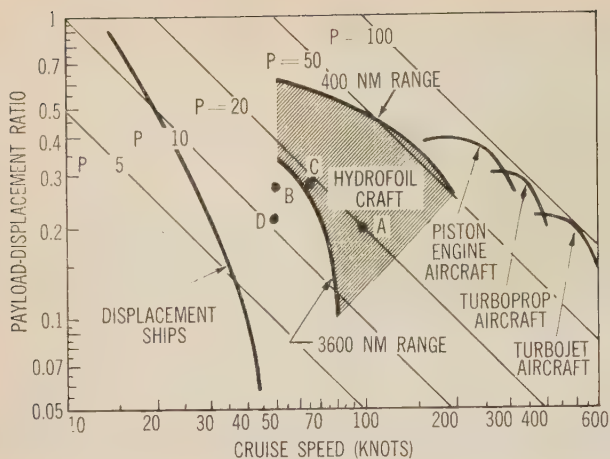
The aim of all these efforts is to make the designs of future ships more efficient. A statistical design approach can, for instance, give ships higher speeds. The same goal, of course, would also be achieved by better propulsion systems.

Higher ship speeds are particularly important, because of the problem of wave-making resistance. At the higher speeds, this effect, N. Friedland, a naval architect at Aerojet-General, told SPACE/AERONAUTICS

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SOME PARAMETERS for several types and arrangements of hydrofoils used that were analyzed in recent Grumman design studies of surface vessels. The graph is for submerged foils at a static margin of 0.05 and 80 knots speed where $d/c=10$ and $K=1$.

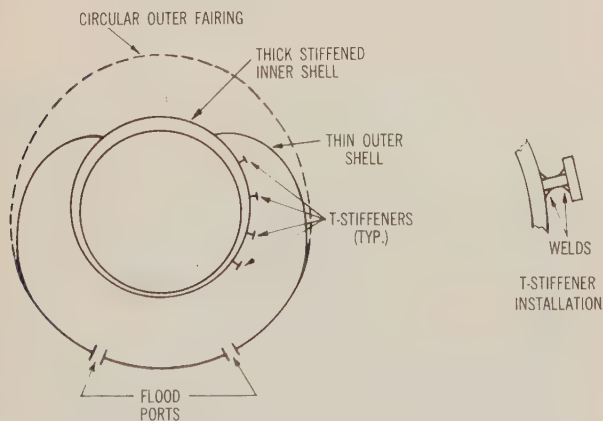


PERFORMANCE of hydrofoil surface craft, as given by L. A. Geyer of Grumman, and G. J. Wennegal, of Dynamic Developments, for various values of productivity (P), which equals the product of payload and speed divided by displacement, and efficiency (E), which equals the product of payload and speed divided by horsepower. The graph in the center assumes a subcavitating foil system, a water propeller, a submerged, pod-mounted nuclear powerplant, and un-

limited operating range. The points in the graph at left give values for four theoretical hydrofoil designs studied by Grumman engineers: A—500 tons displacement, 100 knots cruise speed; B—500 tons displacement, 50 knots cruise speed, 3600 nm range; C—1000 tons displacement, 65 knots cruise speed, pod-mounted nuclear engine; D—3000 tons displacement, 50 knots cruise speed, hull-mounted nuclear engine.



NEW CIGAR SHAPE of advanced sub designs is shown in rough sketch of Polaris-launching George Washington. This sub's structure is basically series of cylinders.



CONVENTIONAL sub hull structure (heavy lines) uses a thin outer shell that acts as a fuel fairing and a thick, stiffened inner shell. Stiffeners are placed on the outside wherever possible to leave more space inside for plumbing, and the like. This cross-section was based on the old-type sub that spent most of the time on the surface. For new subs, which stay submerged most of the time, cigar shape is better, with the outer shell becoming a complete circle (dotted line).

causes the water resistance to go up on the order of the fifth power of speed. With their low speed range, large ships today must slow down in certain seas because of synchronism with the wave frequency. If these ships could go faster, so that they would always be beyond the range of synchronism, they could maintain high speeds more consistently. However, Friedland notes, the liner United States would need something like 1,000,000 hp to achieve the necessary speed.

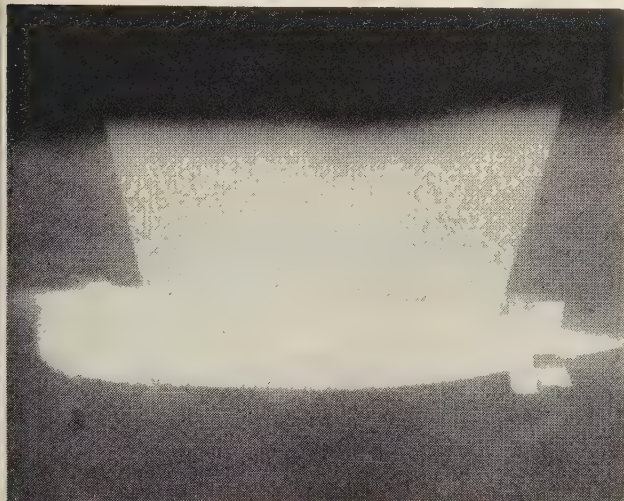
Nuclear engines are prime hope

Among the features under consideration for ships with very high speeds are exceptionally long, slender shapes and fins on the ends to damp out pitching and rolling. The prime hope, though, is the unlimited power potential of nuclear engines.

Since wave-making resistance is no problem underwater, it provides an argument in favor of undersea ASW craft. However, submarine design also has its speed problems. To start with, there are ballast tanks. Possibly these could be replaced by dynamic surfaces corresponding to the airplane wings. One way of applying this "dynamic submersion" approach would be to use wings designed to give negative lift as they bite into the water. They would thus combat the normal tendency of the sub to rise to the surface.

Once you go below the water surface, you also run into cavitation (see "Cavitation Problems Loom Large in Underwater Missile Design, p. 77). Cavitation in

creases with speeds and decreases with depth in the water. It's generally agreed, J. Levy, head hydrodynamicist at Aerojet's ASW Division, told SPACE/AERONAUTICS, that hydrodynamicists must learn to live with cavitation and actually make use of it in their designs. It's especially difficult, he notes, to suppress cavitation on any surface supposed to develop lift, like wings, propeller blades, etc. What can be done to overcome this difficulty is shown by the supercavitating propeller, which remains fully in contact with water on the side that pushes and develops a full cavity on the compression face. Ultra high speed subs of the future may well have hulls designed so that the forepart opens up a full cavity around the vehicle. (Such a submarine de-



ASW DESIGN under test in Aerojet-General's ring channel tank, which has a 12-ft maximum depth and a top speed of 100 knots.

sign, too, would require tremendous power.)

Hydrofoils are receiving a great deal of attention in the design of ASW seaplanes and surface ships. They are under consideration, Leo Geyer, of Grumman, told SPACE/AERONAUTICS, for both surface-piercing and submerged use. In the former case, they are fixed, and the only way to change the lift on them is to change their position in the water. The only way to get stability is to raise or lower them in the water. Submerged foils have electronically controlled, movable surfaces.

Higher horsepower for hydrofoil

Designs derived from aerodynamic developments, such as boundary layer control, are also being considered for hydrofoil craft, which have already profited according to Geyer, from the application of copter gearing development to their power transmissions. The most fundamental requirement of hydrofoil design, however, are higher horsepower engines, Geyer states. GE, P&WA, and others he reports, are interested in taking a gas generator (e.g., the J57) and putting a free-power turbine behind it.

Present submarine construction uses both ordinary

structural steel and some high strength tensile steels. However, with the trend towards operating at much lower depths, the weight of stiffened steel structure becomes a problem. As a result, aluminum is being seriously considered for sub. Reynolds' new Aluminaut deep-water research vehicle, for instance, which is slated to take a three-man crew to depths of 15,000 ft, will be made of aluminum.

Structural plastics may be used

One problem with aluminum is that new methods of welding must be found for six-inch-thick plate required for subs operating at great depths. Many alloy steels are of course also still of interest, though the same welding applies in their case.

Moreover, these alloys get much of their strength from heat-treat, whose effects are canceled by high welding temperature. The weld area also can be a source of corrosion and embrittlement. Corrosion is also a problem with aluminum.

In the end, structural plastics may be the answer for great (but not extreme) depths. Titanium is also very interesting to submarine designers—but it saddles them with a cost problem, they say.

Plastics are also of interest from a detection standpoint. Coleman Engineering, for instance, has reported a technique for depositing a rubberized fabric on a vehicle surface to prevent pinging, and Zenith Plastics, of Gardena, Calif., is said to have developed a plastic for submarine hulls that is non-magnetic and non-pinging and has a compressive strength of 6000 psi.

Detail design becomes critical

A major problem in designing for great depth is that submarine structures are very sensitive to deviations from concentricity and to openings in the hulls such as sea valves. The detail design of even the smallest component can be critical. In one case, the failure of a 3/8-in. plug in a sea-water line caused such an influx of water into the sub that the sea valves had to be closed. A massive redesign job is now underway to rid the outer hull of hand holds, cleats, etc.

For the design of future subs that will operate at extreme depths, more hydrodynamic data are badly needed. The importance of such data was shown up by recent measurements in very deep water, Dr. Knauss, of the Scripps Institute of Oceanography explained to SPACE/AERONAUTICS.

Using indirect methods, researchers had assumed that currents in the area in which these measurements were taken flow at 0.1 cm/sec. Now the measurements make it look as though the actual flow speeds are 50-100 times higher. In terms of the structural weight of a sub, the difference between flows of 1/2 and 1/4 knots, Knauss notes, is considerable.

The most obvious change in sub design has been the one in outer shapes. The subs of World War II were designed to spend most of their cruising time on the surface. They were basically surface ships that could dive underwater for short periods. To decrease their wave-making resistance, they were filled out at the ends.

Nuclear power since then has made true underwater vehicles possible and with them the application of new hydrodynamic principles. These have resulted in the cigar-shaped sub hull.—End

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Cavitation problems

loom large in underwater missile design

- Drag coefficient depends only on cavitation number
- Nucleus content influences development of cavities
- Cavitation seen as violently oscillating process

by **Robert H. Oversmith,**

Hydrodynamics Engineer, Hydrodynamic Model Basin,
Convair Div., General Dynamics Corp.*

THE hydrodynamic problems of bodies traveling underwater at low speeds—50 knots or less, say—can generally be studied with the help of the classical aerodynamic theories and techniques for incompressible fluids. The same approach, however, generally cannot be used for underwater flow at high speeds, as with underwater missiles moving at 100-300 knots. In this case, underwater cavitation complicates the problem.

Cavitation is peculiar to the flow of liquids—it does not occur in the flow of air or other gases. Cavitation takes place when the local pressure at any point within the flow is reduced to the order of the vapor pressure of the water. Vaporization then starts, resulting in a two-phase flow system.

Cavitation of a body may occur in two general forms:

* Hydrodynamic Model Basin, Convair Div., General Dynamics Corp., San Diego 12, Calif.

more on next page

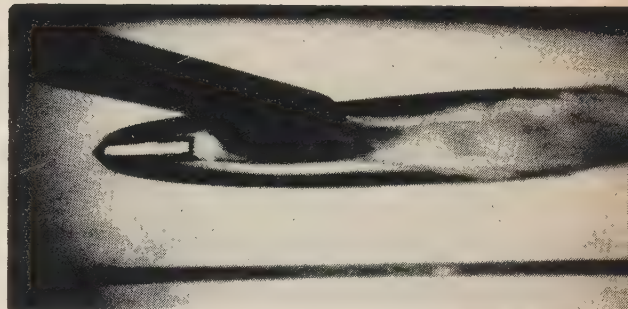
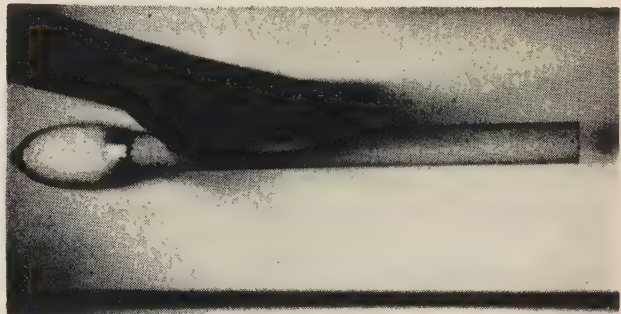
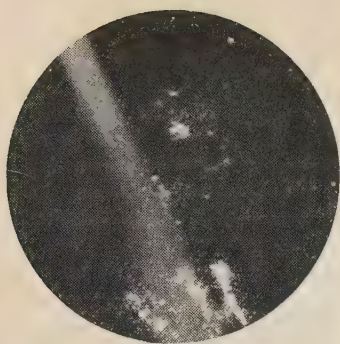


FIGURE 1: Cavitation can be either incipient (top) or fully developed (bottom). The former consists of an aggregate of minute vapor bubbles that collapse after having been carried a short distance downstream. In fully developed cavitation, flow separation develops in front of the zone of previous incipient cavitation, and many small bubbles merge into a single, large cavity bubble. Such full-cavity flow occurs at lower local pressures than does incipient cavitation—for instance at increased speeds or shallower depths.



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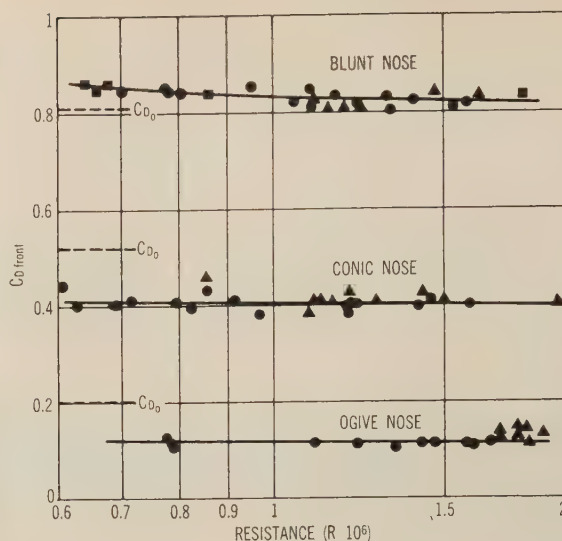
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CAVITATION . . .



STEADY-STATE drag coefficients for three models in non-cavitating flows (bullet and incipient-cavitation flows (triangles). The squares show unpublished aerodynamic data.

• *Incipient cavitation* consists of an aggregate of minute vapor bubbles that develop in regions of low pressure and then collapse only a short distance downstream, where the flow has carried them into regions of higher pressure (Fig. 1).

• *Full-cavity flow, or fully developed cavitation*, occurs when even lower local pressures are reached (as at increased speeds or shallower depths). Flow separation develops in front of the zone of previous incipient cavitation, and the many small bubbles merge into a single, large cavity bubble. Depending on speed, depth, etc., this single bubble may expand so drastically that it completely envelopes the body and leaves only the body's nose wetted (Fig. 1).

Tests at 4 g acceleration were made

The onset of cavitation of an underwater missile is a serious problem for several reasons. There may be an appreciable increase in drag, which will directly limit acceleration and top speed. Serious stability and control problems may occur when the afterbody or its control surfaces partially or completely lose contact with the cavity interface. High intensity underwater noise may be generated through the violent collapse of cavity bubbles. This noise may directly interfere with the operation of homing guidance or alert the enemy. Finally, cavitation can cause structural damage to the point of mechanical failure.

To date, much experimental and a limited amount of theoretical work has been done. Essentially all has been concerned with constant-velocity, steady-state flow conditions. Virtually no research has been done on cavitation in rapidly accelerating motion, largely because of equipment limitations.

Convair's relatively new hydrodynamic model basin, however, which can produce four-g acceleration, now permits such studies. A series of tests recently were completed at speeds as high as 108 ft/sec and accelerations up to four g (Fig. 2).

For a given body in steady-state full-cavity flow, it's now well established that the drag coefficient (C_D) is a function solely of a dimensionless parameter known as the cavitation number (K) and is given by:

$$K = (p_o - p_{cav}) / q,$$

where p_o is absolute static pressure at depth of model in undisturbed water; p_{cav} , pressure in cavity; and q , dynamic pressure, or $\frac{1}{2} \rho V^2$.

Just as the Reynolds number (R_N) is the significant dimensionless parameter for correlating steady-state drag in incompressible, subsonic aerodynamic flow, K is the correlating parameter for C_D in steady-state fully developed cavity flow underwater.

Many researchers have theorized that K alone is also sufficient to describe the cavity size and contour in the case of steady-state cavity flow. Tests have borne out this assumption. Our definition

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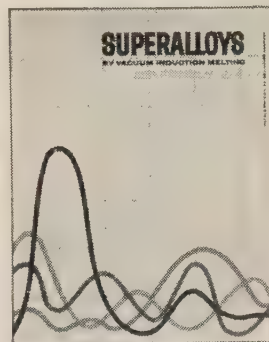
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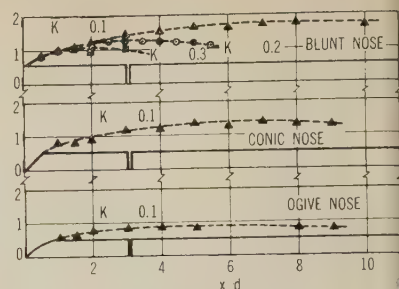


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CAVITATION . . .



CAVITY CONTOURS for the three nose arrangements of Figure 3 in steady-state full-cavity flow. Note the close agreement of the air and vapor cavity measurements (solid and open symbols, respectively). However, this type of gas does affect the extreme down-stream end of cavity because both uncondensable and condensable gases are involved. Comparison data for $K = 0.2$ and $K = 0.3$ were published by Rouse and McNown in University of Iowa Bulletin 32 ('45).

K makes this relationship clear—it is the pressure differential ($p_o - p_{cav}$) that returns the cavity boundary toward the axis after the water has at first been deflected by the body. It follows that reduced values of K give less longitudinal curvature of the cavity wall and therefore longer cavity bubbles. The special case in which K equals zero theoretically implies a non-closing cavity which extends to infinity.

However, these last statements about K may not be valid for the far downstream end of the cavity in the region of turbulent mixing of water and gas. Here, R_N effects in the turbulent wake may be important. On the other hand, in the case of steady-state incipient cavitation, K is also regarded as a significant correlating parameter for C_D .

We should also note that the mass flow rates of gas within fully developed cavities are very low. It therefore ought to be possible to replace the cavity vapor with any gas at the same pressure without affecting the drag or cavity contour. Air-supported cavities have been studied by several researchers, who have found a close correlation with vapor cavities.

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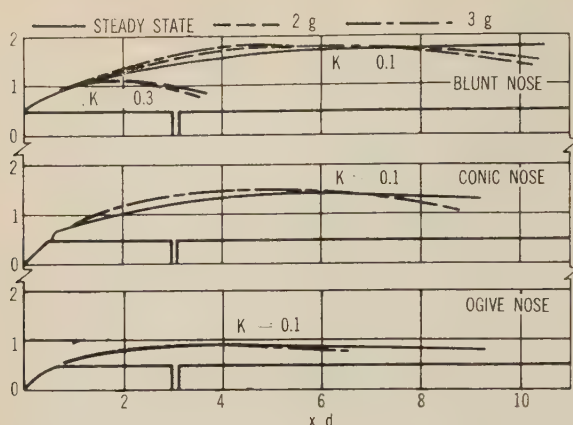
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CONTOURS of full-air and full-vapor cavities in accelerated motion. These envelopes were averaged from many runs. The data show that accelerated motion produces cavities with slightly larger maximum diameters and shorter lengths than do steady-state conditions.

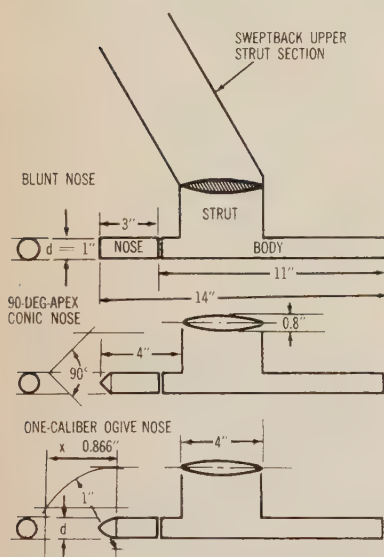


FIGURE 2: Three of the models used in Convair's tests. The strut is a 6061-T6 aluminum extrusion with a cross-section similar to NACA 661-012. Extensive evaluations showed the effects of strut interference on cavitating flows is small.

vapor cavity would require over 90 fps. The advantages of low test speeds include easy flow observation, longer data recording periods, and reduced strain on the apparatus.

One noteworthy observation we made on cavitating flow under rapidly accelerating forward motion was that incipient (vapor) cavitation occurred very early and at surprisingly low velocities. In the four-g maximum acceleration test, cavitation was actually produced by a conical nose at only 12

fps after the model had traveled a mere 0.6 ft from rest. However, this result wasn't always duplicated in repeat runs with the identical velocity-time histories. In some runs, cavitation wasn't visible in photographs until speeds of up to 43 fps had been reached.

A plausible reason for this inconsistency in the start of cavitation can be found in the role of the cavitation nuclei in the formation and growth of cavities. It's now generally accepted that the origin of cavities is associated with the enlargement of air, gas, or vapor nuclei present either by themselves or in conjunction with solids. Also, the nose sections of the moving body itself might be a source of gas or vapor nuclei.

Unfortunately, no methods or equipment have yet been developed for measuring this nuclei content. Since in our tests no steps were taken to control the quality of the water, it's probable that the nuclei content varied over a wide range.

We also observed similar inconsistencies in the speed at which full-vapor cavities began to form. With the conical nose, a full-vapor cavity was obtained in one run at 91 fps, while in others no such cavity developed at speeds as high as 108 fps. It's hard to understand how, once the incipient bubbles are present, the nuclei could appreciably affect the transformation to full-cavity flow, though perhaps the nuclei content does influence the time rate of the transformation.

We also considered other explanations. For instance, minor leak-

more on page 86



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Vought's oceanographic studies are designed to discover new, usable information about the submarine's environment. The lay of the land thousands of fathoms down is important in finding and fighting subs.

Fleet subs and aircraft are being operated for Vought in other tests. Under contract with the Office of Naval Research, company scientists and engineers are investigating sub detection techniques which employ new phenomena.

Vought's weapons-wise design and manufacturing teams can be counted on to transform the newest findings into complete and effective defensive systems, in whatever direction ASW studies lead.

Antisubmarine warfare, along with atmospheric missile and piloted aircraft development, are specialties in Vought's Aeronautics Division. Other major interests are being aggressively advanced in the company's Astronautics, Electronics Research, and Range Systems Division.

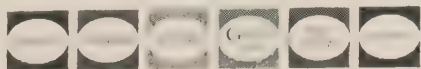
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CAVITATION . . .

age of air down through the model's strut into the cavity region could prevent the attainment of pressures low enough to sustain full-vapor-cavity flow. However, close examination of the test records showed that p_{cav} was the same regardless of whether the cavity flow was incipient or fully developed.

The cavitating process is violent

We took high-frame-rate movies at about 2000 pictures per second and projected them on a screen 120 times slower than the real time rate. These movies revealed some unexpected properties of cavitating flows. In general, we could see, the whole process is not smooth but characterized by violent, unstable oscillations. There were continuous abrupt expansions and contractions of the whole envelopes of cavitation. We estimated that the diameters of these envelopes varied as much as ± 25 per cent from the time-averaged values.

In addition, at a speed of about 80 fps in a typical maximum-acceleration, top-speed run (four g, 10 fps), the envelope of the incipient cavitation began to clear from the front as though a single, large cavity bubble would form. The model nose became visible through the interface only momentarily, however, as the envelope contracted. Then abruptly, the envelope enlarged and appeared to fill up completely with minute, discrete vapor bubbles. Alternating partial clearing and filling—at a frequency of about 40 c—persisted throughout the rest of the run, and a stable full cavity was never sustained.

Froth envelopes were rough and irregular

Close examination of individual frames, which had exposures of 1/4000 sec, showed that the envelopes of the froth were quite rough and irregular, while the interfaces of the cleared regions were reasonably smooth. By comparing the walls of fully developed supported cavities were quite smooth and regular.

In other tests, underwater exhaust flow simulated by blown compressed air from the model tailpipe had no significant effect on the flow upstream of the tailpipe. This held true for all types of flow.—End



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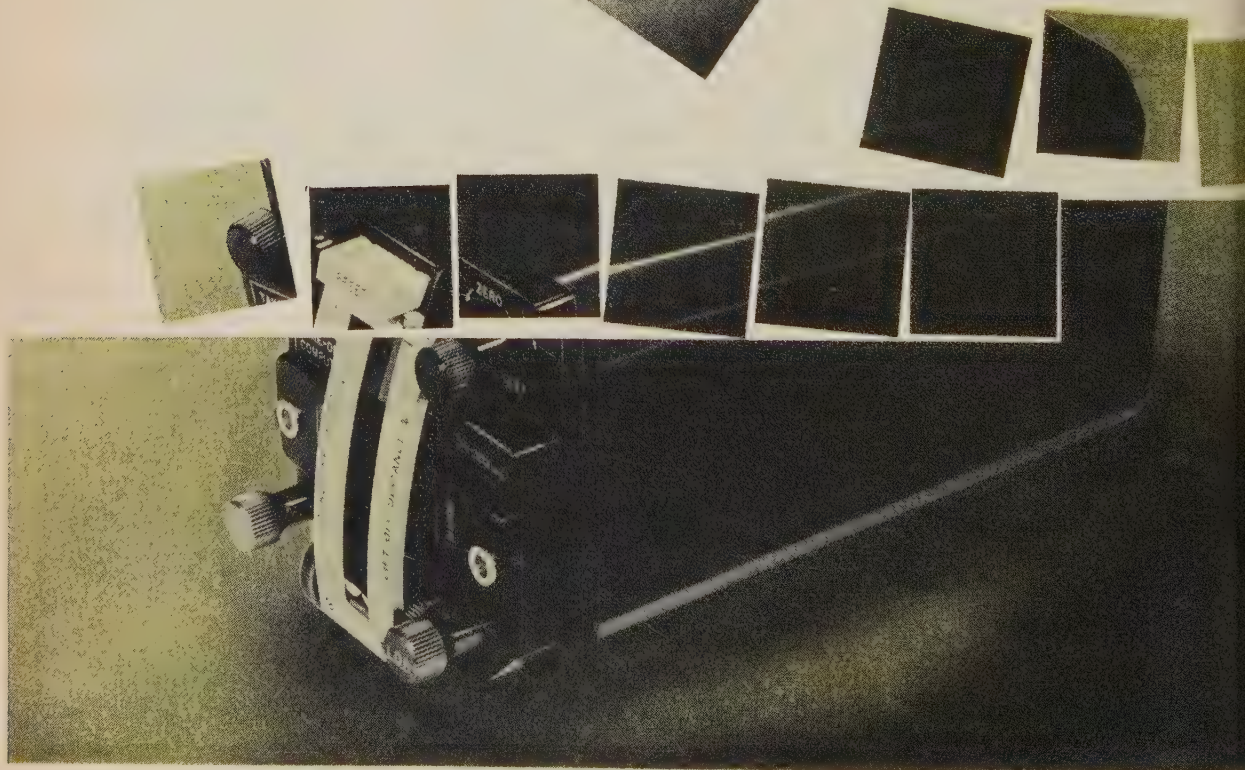
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by **Richard L. Beam,**
Executive Vice President-Engineering
Hazeltime Electronics Div., Hazeltime Corp.

A HYDRO-ACOUSTIC test tank facility has been set up by Hazeltime to test the sonic response of sonobuoys and sonar system transducers. This facility, one of the few of its type that is in operation today, also will be used for basic research into other devices for detecting and tracking submarines.

We had three choices when we had to decide on a test facility for our hydro-acoustic work: (1) a salt-water body—in our case, Long Island Sound, (2) a fresh-water lake, and (3) a tank. The Sound was too noisy—too much ship traffic. There was no suitable lake near any Hazeltime engineering facility that could have been used without difficulty. A tank met our need for a controllable, all-weather test facility.

In determining the size, depth, shape, materials, and instrumentation of the tank, Hazeltime engineers relied on reports issued by the Navy's Undersea Warfare Division. These suggest that the ideal sonar tank should

Hazeltime Electronics Div., Hazeltime Corp., Little Neck, N. Y.

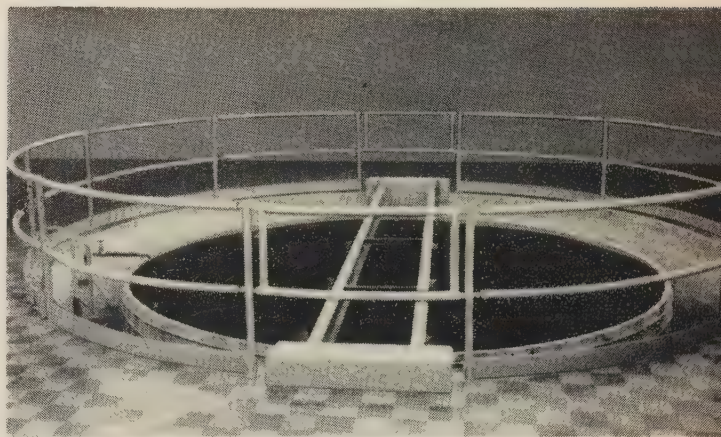


FIGURE 1: Sonar test tank at Hazeltime's Greenlawn, N.Y., engineering laboratory is 20 ft in diameter, 12 ft deep, and holds 125 tons of water.

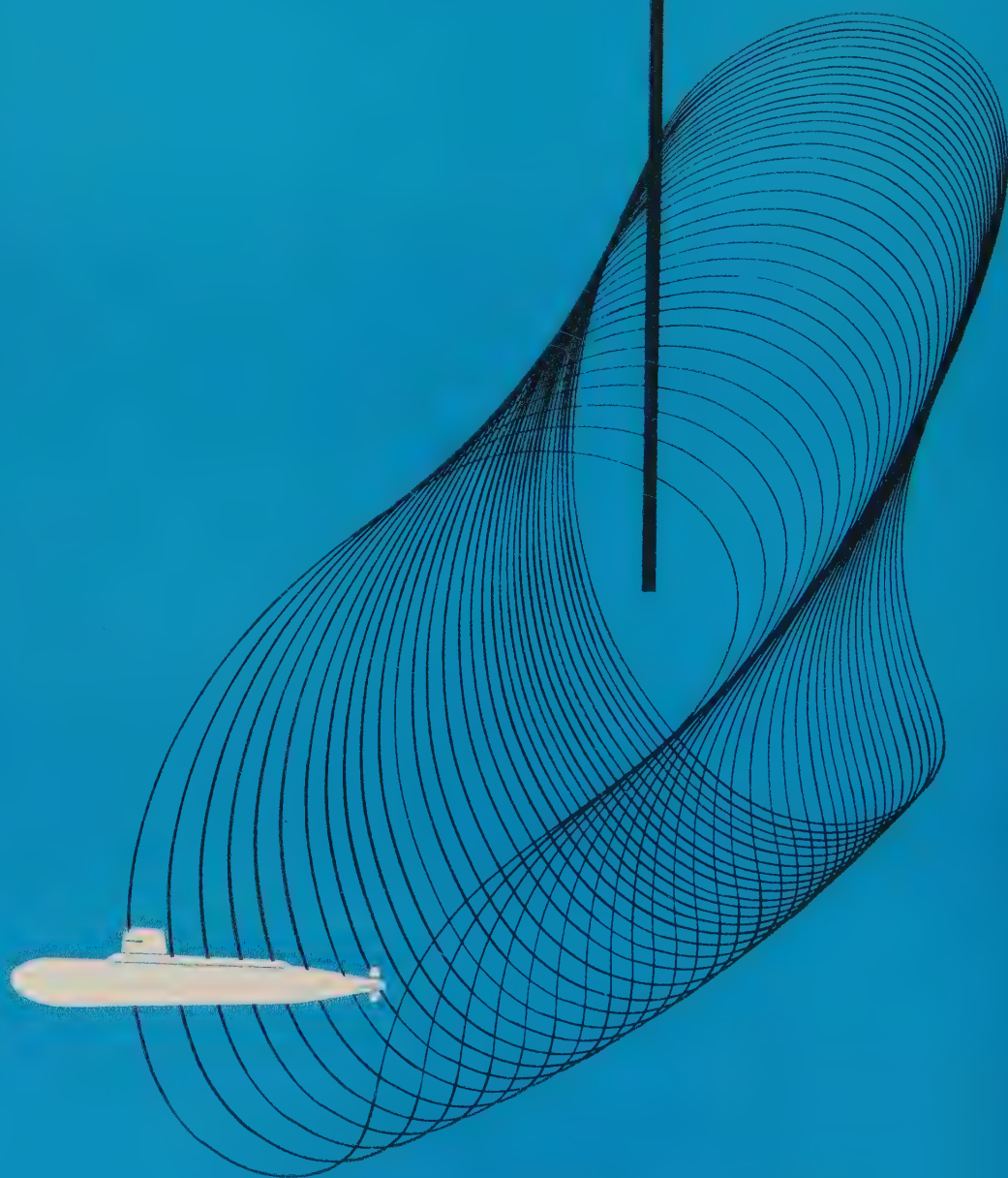
be elliptical. If a projector and a hydrophone are placed at the foci of an elliptical tank, the reflections from any point on the tank wall will arrive at the hydrophone at the same time. Reflection problems then are easily pinned down.

Structural problems in building a perfect ellipse and providing proper support made the elliptical tank shape uneconomical. The tank we actually built is circular (*Fig. 1*). Twenty feet in diameter and 12 ft deep, it holds 125 tons of water. Fresh water is used, since tests have shown that fresh and salt water give equivalent results.

The main problems in building the tank were to insure the simulations of the impedance of the ocean by reducing sound reflections and to limit the transmission of outside noises into the tank. Made of 2½-in. white cedar, the tank sits on wooden sleepers. These rest on a four-inch layer of cork. The cork in turn is supported by a concrete slab isolated from the rest of the building.

more on page 91

*A TALENT FOR UNDERSEA
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SPACE/AERONAUTICS

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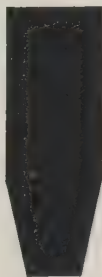
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TEST TANK . . .

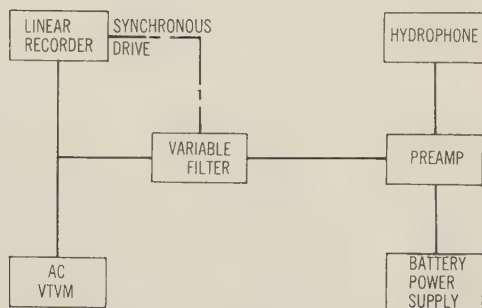
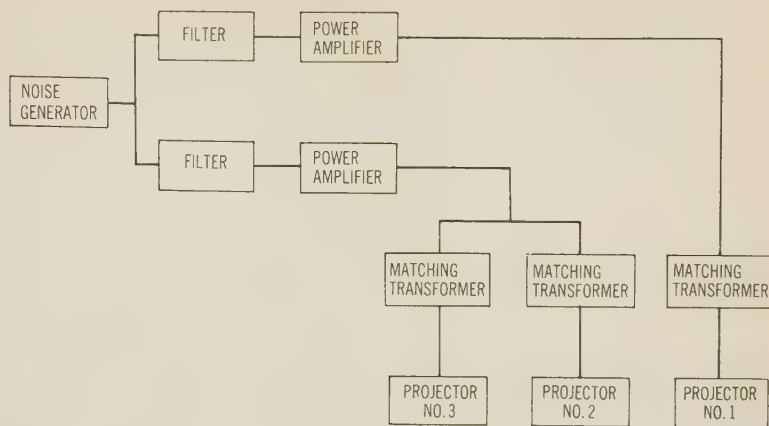


FIGURE 2: Noise system of Hazeltine's tank is used for automatically recorded sensitivity-vs-frequency measurements.

This construction is designed to reduce interference from noises in the building.

White cedar is used because of its relatively high porosity. The 2½-in thickness is needed to contain the water.

With tank walls of white cedar, you might expect an almost perfect reflecting surface causing prolonged reverberation. This effect actually is present when the tank is first filled. Then trapped air starts to coat the wall with air bubbles. In time, the wood gradually is wetted and absorbs the water.

Impedance gradient through wooden wall

The result is an impedance gradient through the thickness of the wood—the high impedance of water gradually is reduced to that of air. Reflections at the tank walls therefore are minimized, and the reverberation time in the tank is reduced.

The tank will be used to measure the acoustic output, efficiency, sensitivity, frequency response, and directional characteristics of sonar

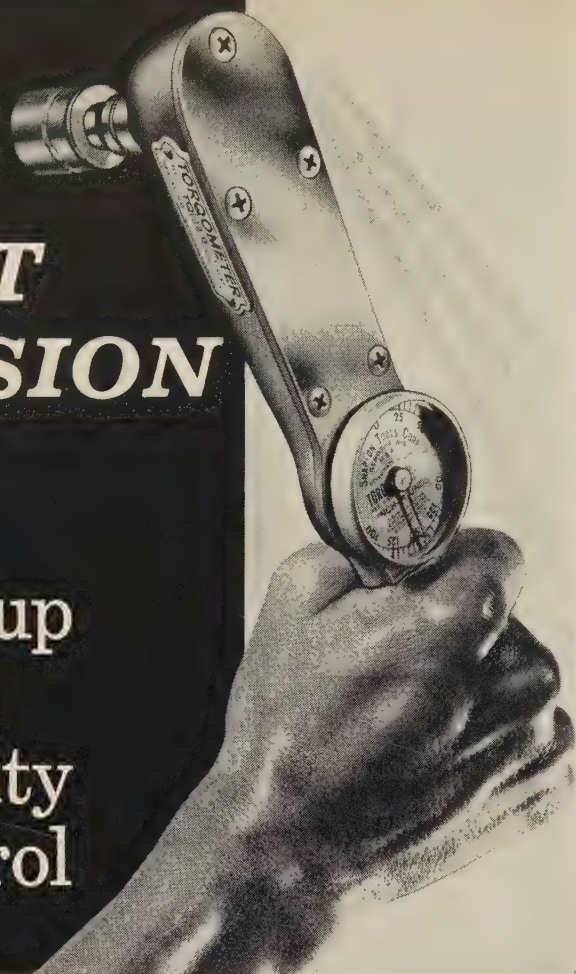
transducers. Two test systems will be used: a noise system and a pulse system.

In the former, a noise field, containing all frequencies in the band to be measured, is generated in the tank (Fig. 2). The noise signal is fed to power amplifiers through filter. These modify the shape of the transmitted signal spectrum. The amplifiers feed a number of projectors through matching transformers. Several projectors are used because each operates effectively only over a rather restricted band within the frequency range of interest. The projectors are combined in such a way that a signal spectrum of uniform level is produced in the tank. The signal is picked up by a hydrophone and, after amplification in the pre-amplifier, fed to a variable electronic filter for analysis. This bandpass filter sweeps over the entire frequency range of interest. The output of the filter is supplied to a recorder and to an ac vacuum-type voltmeter (VTVM). The filter and the linear recorder are driven synchronously. A random noise field is used to re-

more on next page

BOLT TENSION

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with
quality
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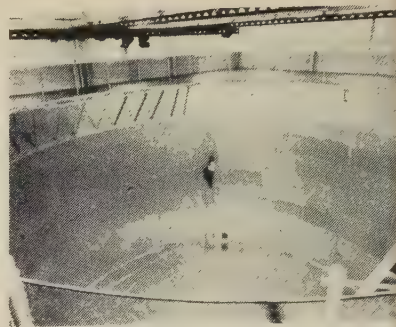
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CORPORATION

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TEST TANK . . .



AT THE other end of the sonar-test-tank spectrum from the relatively simple facility at Hazeltine are such huge installations as the 400,000-gal tank built by Stromberg-Carlson for \$250,000. With a diameter of 48 feet and a depth of 30 ft. this tank is said to be the largest of its kind.

duce the effects of standing waves and surface reflections.

In the pulse system, an audio generator produces a continuous signal at a single, preselected frequency (Fig. 3). This signal is fed to a modulator that gates it on and off. The output of the modulator is then fed to a power amplifier, which raises the level of the signal. Then the signal is transmitted through a matching transformer to a projector in the tank, picked up by a hydrophone, and fed to a pre-amplifier. The latter, located close to the hydrophone, amplifies the hydrophone signals for transmission to the remote receiving equipment at a low impedance level.

Gated receivers fulfills three functions

The receiving equipment includes a gated receiver that amplifies the signal, gates itself on at the proper time for the reception of the incoming signal, and stores the signal (between the gated pulses). The output of this receiver is supplied either to a recorder or to a dc VTVM. Signals reflected from

more on page 94



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TEST TANK . . .

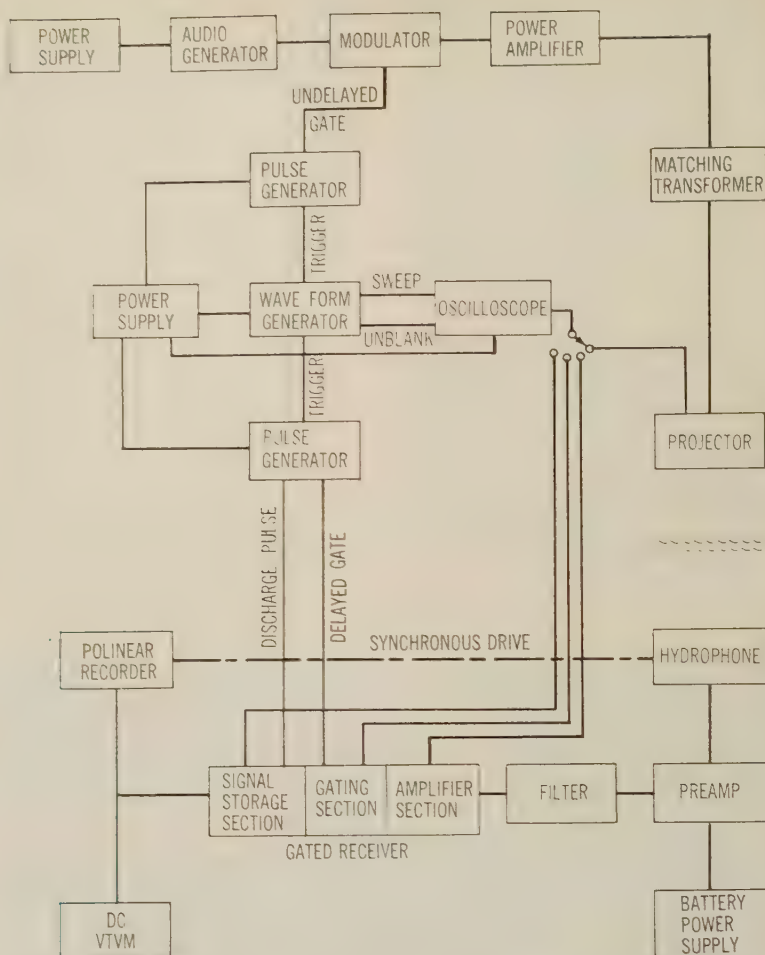


FIGURE 3: Pulse system is used for beam-pattern and sensitivity-vs-frequency measurements.

the tank walls are eliminated by the proper gating of the receiver.

The maximum usable pulsewidth is determined by the time of arrival of the first reflection—a direct pulse must be completed before the first reflection pulse arrives. This arrival time is a function of the tank geometry.

Minimum carrier frequency is 10 cycles/pulse

The lowest carrier frequency that can be inserted in the maximum pulsewidth depends on the processing ability of the receiving equipment. For our tank, we arbitrarily chose the minimum carrier frequency as 10 cycles per pulse.

Water depth usually is the factor controlling the pulsewidth limit, since bottom reflections are the first to return to the point of measurement. With a nine-foot-deep tank, a maximum pulsewidth of one millisecond is needed to separate direct and reflected pulses. A

12-ft-deep tank permits the use of a two-millisecond pulsewidth. A nine-foot-deep tank has a low carrier frequency limit of 10 kc, while that of a 12-ft-deep tank is five kc.

In the noise system, the lowest frequency is limited by the diameter of the tank and the power available to the projector at the lowest frequency. Our tank is resonant at about 400 cps, but can be used with reduced efficiency at frequencies down to about 200 cps.

Measures from 0.2 to 150 kc and five to ten kc

Instrumentation for the tank consists of two power supply units; battery power supply; two power amplifiers; two power generators; three matching transformers; three projectors; three filters, including variable one; audio generator; noise generator; waveform generator; oscilloscope; modulator; polineal recorder; preamplifier; ac-dc VTVM.

more on page 5

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TEST TANK . . .

VM; and audio microvolter. It covers a frequency range from 200 cps to 150 kc for sensitivity measurements and that from five to 10 kc for directivity measurements.

Pressure tank lowered into hydro-acoustic tank

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Comparisons of the three resulting curves show the influence of pressure on the hydrophone. Calibration of the sound pressure field at the test location in the tank is done by means of standard hydrophones.—End



TELEFLIGHT[®]

MODEL 180

AIRBORNE PRESSURE TRANSDUCER

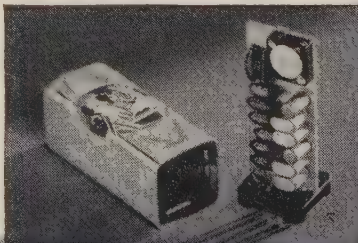
Approximately 3½" long and 10 ounces in weight. The rugged construction of Model 180 makes it the ideal Transducer for airborne applications. BONDED STRAIN GAGE construction results in low sensitivity to vibration or shock in any axis. Proving ring acts as a heat-sink for the strain gages under zero gravity conditions. Resolution is INFINITE. Features standard built-in pressure overload protection. Pressure Ranges: 0-350, 0-750 and 0-1,000 PSI. Linearity 0.3%, Hysteresis 0.25% of F.S. at any given point, Ambient Temperature —100° F. to +2.75° F.

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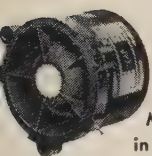
MODEL 214 TRANSISTOR AMPLIFIER

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SPACE/AERONAUTICS



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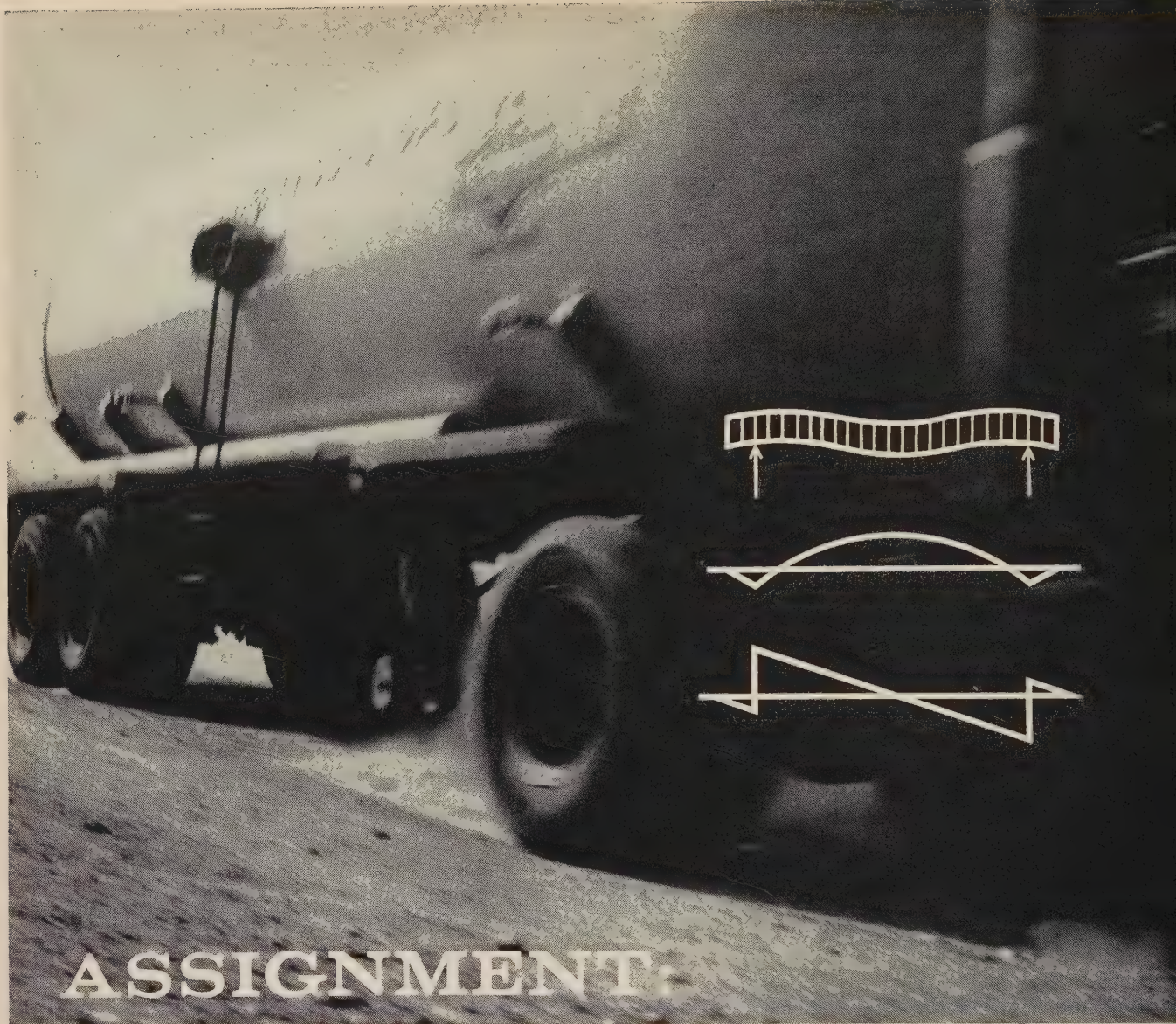


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LPG transport tanks and power shovels are widely divergent areas in which Lukens engineers have helped increase payloads.

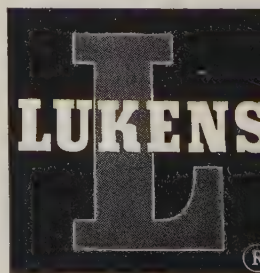
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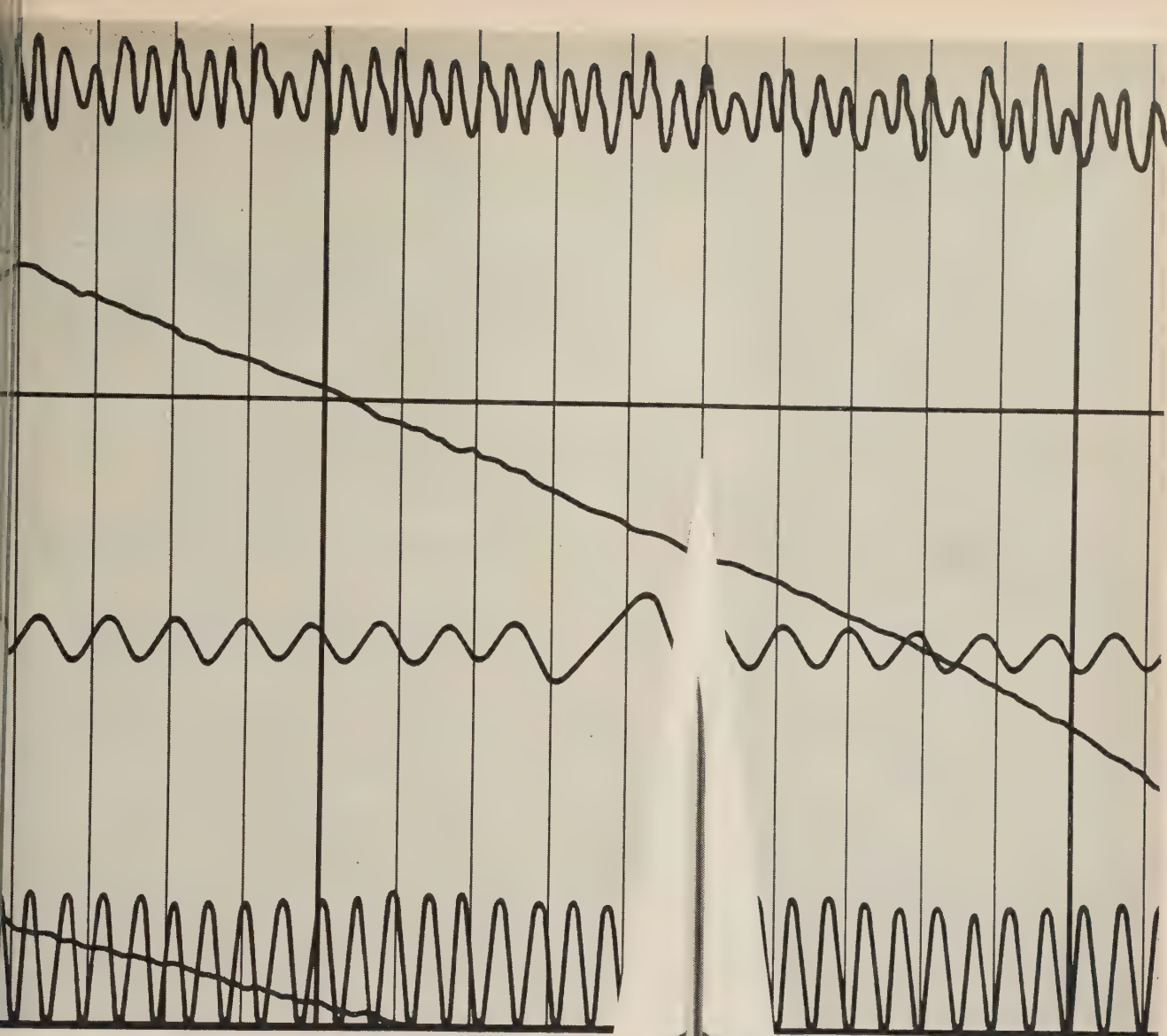
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SPACE/AERONAUTICS



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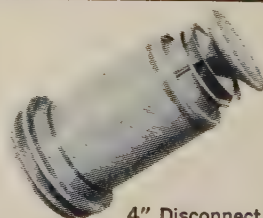
9" Disconnect
with Universal
Fluid Coupling



8" Disconnect Valve



5" Disconnect
(tank mounted)



4" Disconnect Valve

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Undersea weapon system roundup

VIRTUALLY all activities involving offensive and defensive undersea warfare are the responsibility of the Navy. Among the many and highly diverse weapon systems in service has in operation or under development are:

AIRCRAFT

Lockheed's *P2V Neptune* patrol bomber has been the basic anti-sub aircraft for more than a decade. Still in production as the *P2V-7*, it uses two Curtiss-Wright R3350 "Turbo Compound" piston engines and two Westinghouse J34 turbojets. The stinger tail of the *P2V-7* houses MAD (Magnetic Anomaly Detector) gear for submarine location.

Lockheed also is starting production of the *P3V-1*, an advanced ASW aircraft based on the design of the Electra airliner. It is powered by four Allison T56 turbofans.

Grumman's *S2F-1 Tracker* is the first ASW aircraft to combine search and attack elements. It uses two C-W R1820-82 engines and carries depth charges, missiles, sonobuoys, and MAD gear. An advanced version, the *S2F-3*, is under development.

Martin's *P5M-2 Marlin*, using two R3350s, has been in service for more than five years. Martin is making extensive modifications on the T-tailed Marlin to improve its ASW capabilities.

Convair won a BuAer design competition for an *ASW seaplane* in 1957, but has never received a production contract because of limited Navy funds. Despite Convair's long wait and the cancellation of the mine-laying Martin P6M SeaMaster, the Navy has not abandoned the seaplane concept for ASW. Vice Admiral Robert B. Pirie, Deputy Chief of Naval Operations for Air, says the Navy will need a water-based ASW aircraft in the future and believes that one using nuclear power may be the answer. Navy officials expect the *nuclear-powered ASW seaplane* to use turboprops rather than turbojets.

Chance Vought is designing a new *carrier-based ASW plane* that, it hopes, will provide a significant increase in performance. Its approach is to get the greatest effectiveness out of existing or projected detection devices and then integrate these into a fast carrier plane designed from the start for ASW missions.

NON-RIGID AIRSHIPS

Goodyear's *3PG-2W*, which has an envelope volume of 1,000,000 cu ft, is the standard ASW airship used in coastal patrol. It is powered by two C-W R 1300 piston engines and cruises at about 50 knots.

Goodyear has also proposed an ASW version of the 1,500,000-cu

ft ZPG-3W, now used for airborne early-warning operations. It is also promoting a huge nuclear-powered airship that would handle ASW and other missions.

MISSILES, TORPEDOES, ROCKETS

Lockheed's *Polaris* solid propellant fleet ballistic missile will be fired from nuclear-propelled submarines. It can be fired either from underwater or from the surface. Its range will be up to 1500 miles. Its power plant is supplied by Aerojet-General, its inertial guidance system by GE.

Goodyear's *Subroc*, now in development, basically will be an underwater-to-air-to-underwater missile, but it will also be usable as a surface-to-underwater weapon. Fitted with a nuclear warhead, Subroc will be the first true missile to be used by hunter-killer submarines. Its range will be 25-50 miles. The Naval Ordnance Lab is responsible for the development of the weapon, for which Thiokol Chemical is supplying the propulsion system and Kearfott the guidance.

Able is an operational 500-lb, 12.75-in. unguided solid propellant ASW missile mounted on destroyer escorts and frigates. It is fired from a launcher similar to a conventional gun turret and aimed by a special fire-control system. It carries a conventional high-explosive

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Sub-Miniature Type TX Wire Wound Resistors

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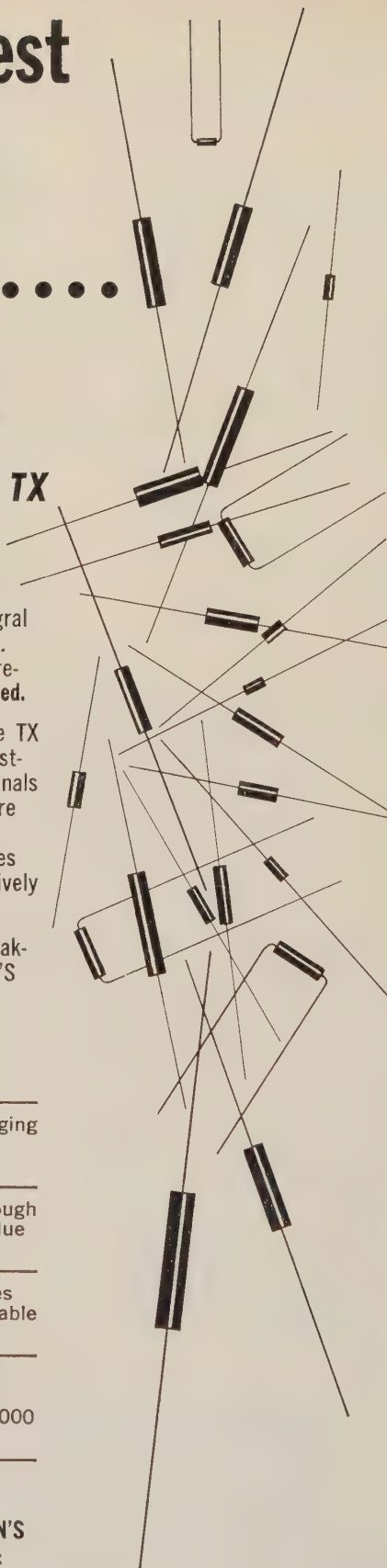
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WEAPON SYSTEMS . . .

charge, sinks rapidly, and covers a large ocean area. Avco is the prime contractor.

Rat, a canceled weapon, was conceived by the Naval Ordnance Test Station as a rocket-thrown torpedo. Librascope supplied the fire control system, Allegany Ballistics the rocket, and Clevite Research Center the torpedo. *Rat* was designed to detect a sub at long range, compute its course and speed, aim a launcher, and fire the rocket-torpedo combination. The rocket, soon dropped into the sea after burnout. The torpedo flew on, stabilized by a parachute, which was shed when the torpedo eventually had descended to the water. The torpedo then started to search for and attack the sub.

Petrel, a Fairchild missile powered by a Fairchild J44 turbojet, is no longer in production. It is used mainly for training pilots in firing air-to-underwater missiles.

Asroc, for which Minneapolis-Honeywell holds the prime contract, is a surface-to-underwater solid rocket torpedo fitted with a nuclear warhead. It is due to become operational early in 1961.

Astor is an underwater-to-underwater rocket torpedo with a nuclear warhead. It's in the R&D stage at Westinghouse-Baltimore.

Vitro Labs is developing a *wire-guided torpedo* for ASW applications. Brush Clevite is working on an ASW *torpedo* using acoustic homing.

Temco has proposed an ASW version of its radar-homing, air-to-surface *Corvus* missile. The *Corvus* will have a range of about 100 miles. It uses a prepackaged Thiokol liquid propellant rocket and guidance by Texas Instruments.

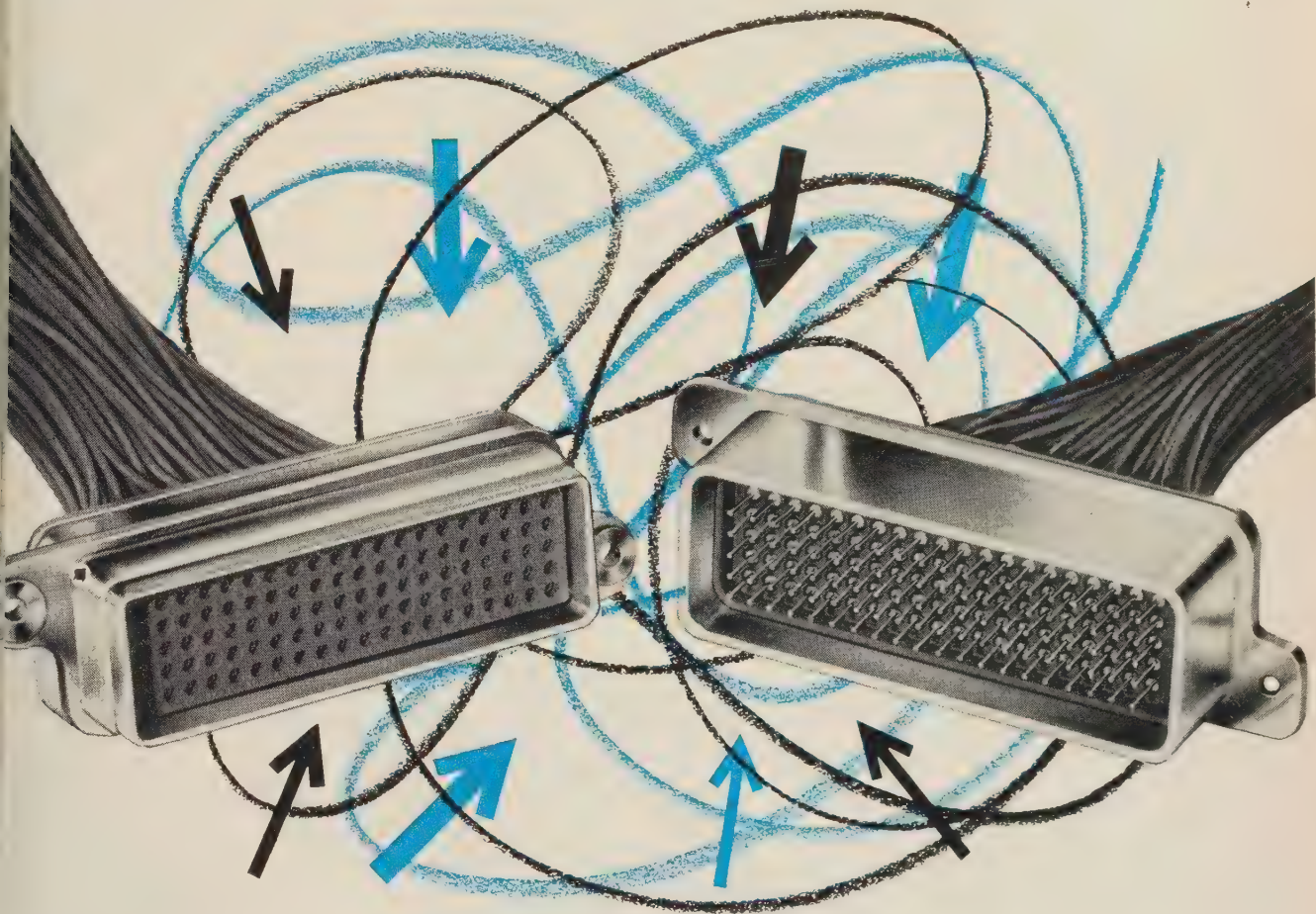
Zuni, an operational unguided air-to-air and air-to-surface rocket developed by the Naval Ordnance Test Station, has been proposed as an air-to-underwater weapon. It has a five-mile range and delivers a conventional warhead.

Lulu and *Lulubelle*, both surface-to-surface nuclear-warhead weapons in the R&D stage, could be converted into anti-sub missiles with a change in guidance techniques.

Regulus I, built by Chance Vought, is already deployed aboard U.S. subs as a 500-mile-range surface-to-surface offensive missile. It carries either a conventional or

more on page 10

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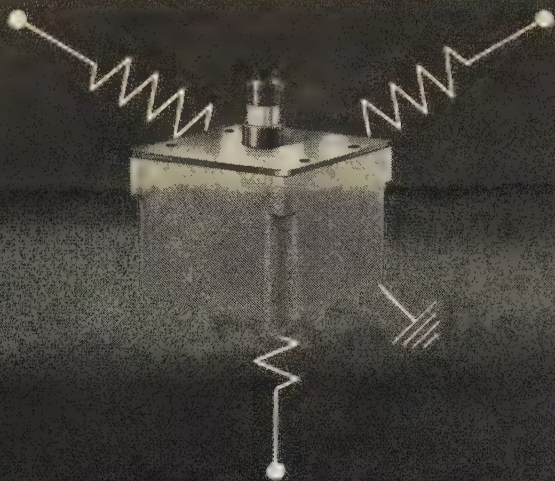
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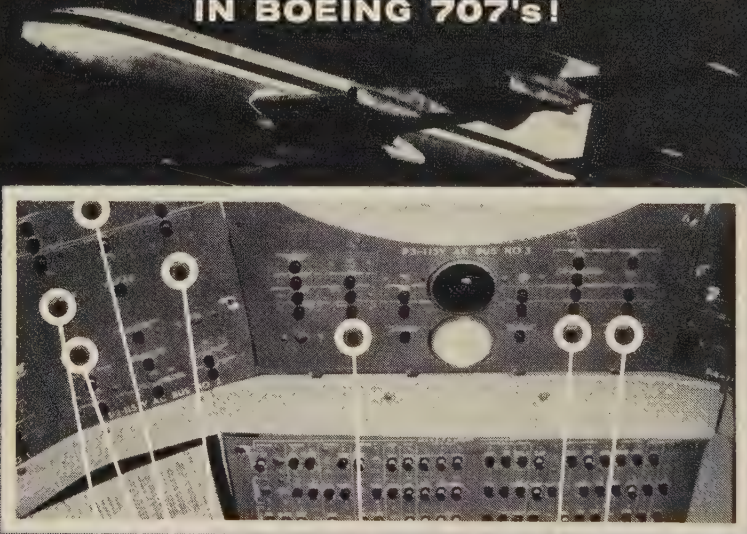
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nuclear warhead. Propulsion is supplied by Aerojet-General (Solid rocket booster) and by Allison (turbojet sustainer). Sperry supplies the guidance. An advanced version, the supersonic, 1500-mile-range Regulus II, was canceled in the light of the Navy's success with Polaris.

The *Lobber* missile, proposed by Convair to the Army as a 10-15-mile cargo carrier, is also being analyzed for ASW applications. Convair believes the *Lobber*, equipped with either a nuclear or conventional warhead, is very attractive as a depth charge. It may also be usable by subs for shore bombardment.

Aerojet-General's ASW Division is developing a new long-range, high-performance *torpedo*. Bendix-Pacific is working with Aerojet, supplying guidance and controls.

SUBMARINES

A total of nine nuclear-powered submarines capable of firing the Polaris are under construction. The Navy is hoping for authorization for more *Polaris* subs in future years. Many of these will also be able to defend themselves against attack by enemy subs by launching Subrocs or other anti-sub weapons.

General Dynamics' Electric Boat Division is fitting out the *Triton* radar picket submarine for sea trials. As far as is known, the *Triton* is the first sub to use two reactors and the largest over built. Although designed primarily as a radar picket ship, she will also have ASW capability and may be the forerunner of a new breed of ASW vehicles.

Electric Boat is also building the *Tullibee*, the world's first known true anti-sub submarine. The nuclear-powered *Tullibee*, and future sister ships will replace the *Sea Leopard* and the *Cubera* ASW submarines now used by the Navy as part of its hunter-killer strength.

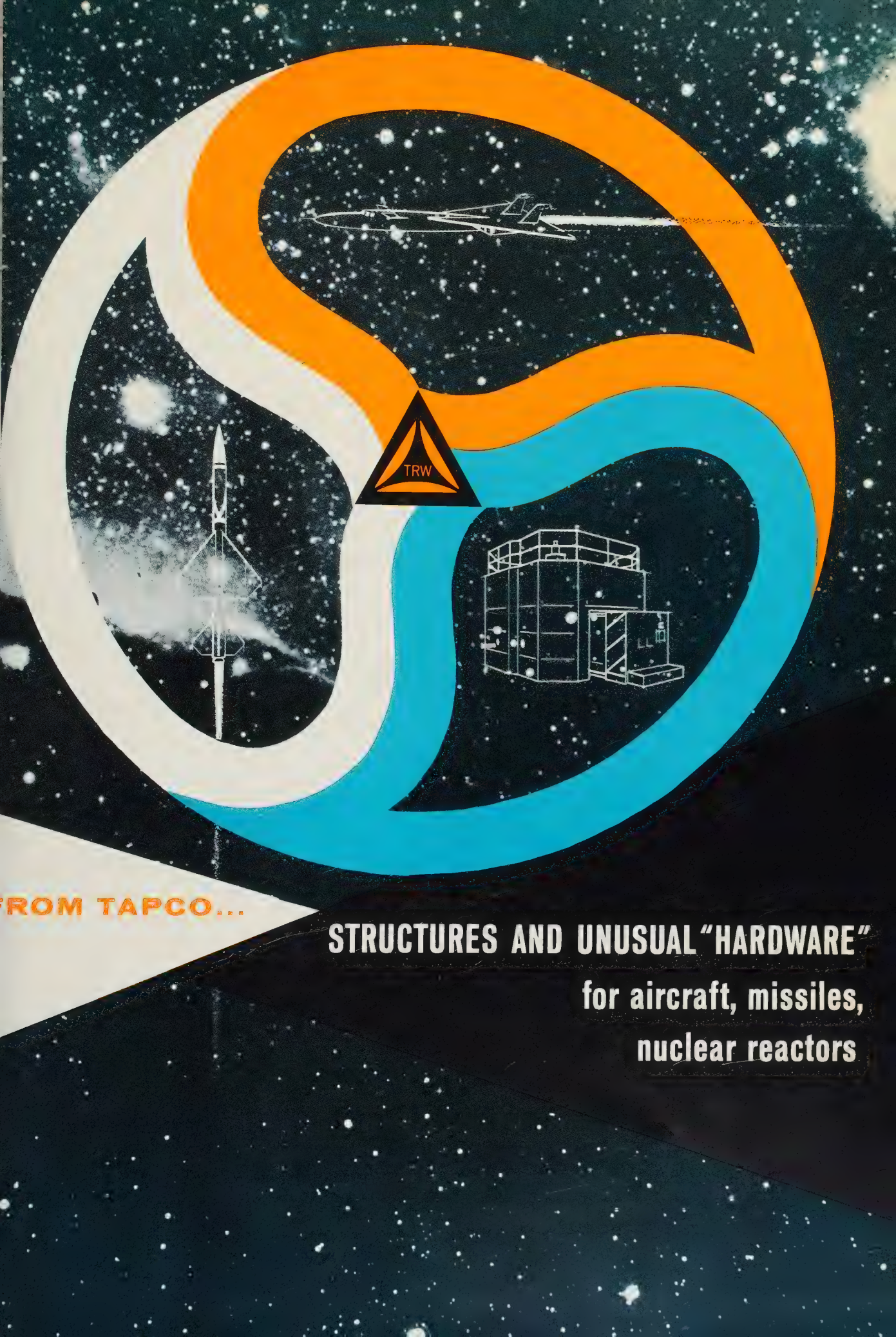
HELICOPTERS

Sikorsky's *HSS-2* twin-turbine helicopter is also in production. Featuring a boat hull, the *HSS-2* can search for and kill enemy subs and operate on a 24-hour basis. It is fitted with four torpedo racks and has nuclear-weapons capability.

more on page 109

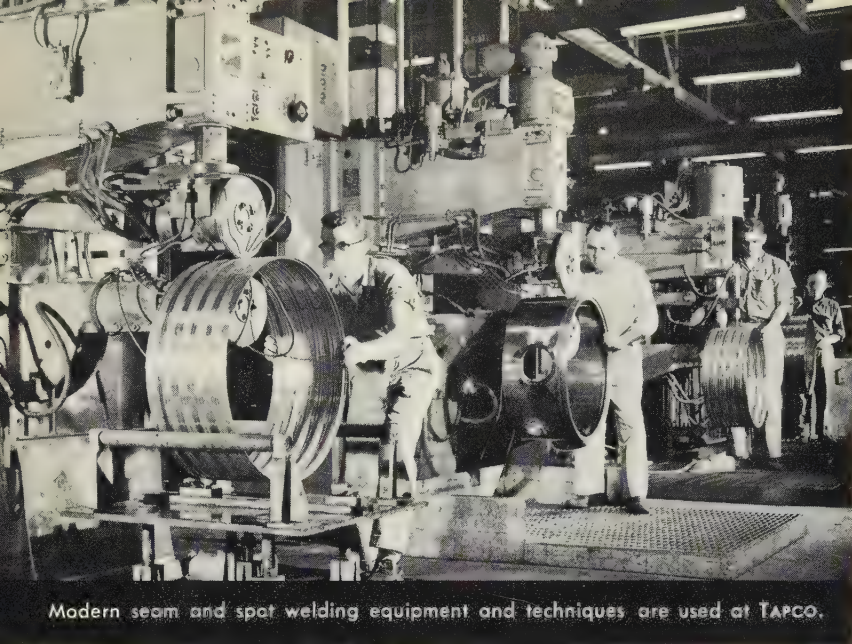
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SPACE/AERONAUTICS

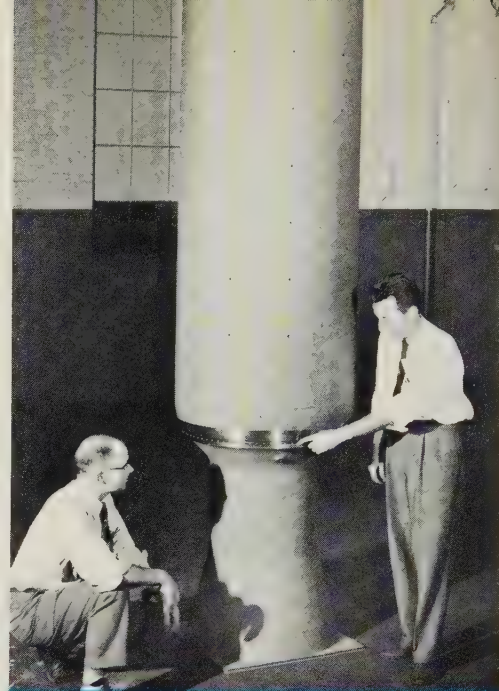


FROM TAPCO...

STRUCTURES AND UNUSUAL "HARDWARE"
for aircraft, missiles,
nuclear reactors



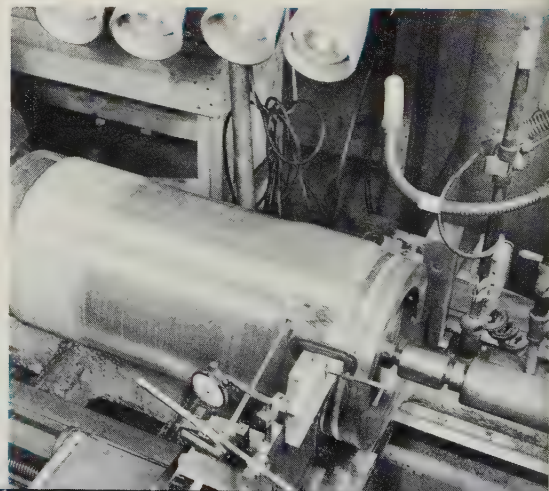
Modern seam and spot welding equipment and techniques are used at TAPCO.



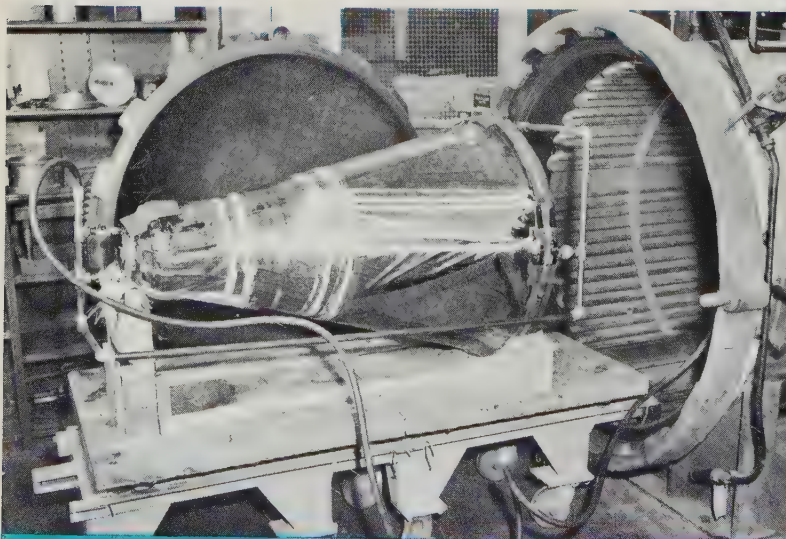
TAPCO's experience in successfully working, forming and welding unusual alloys is illustrated by this high strength case made for a solid fuel rocket engine.



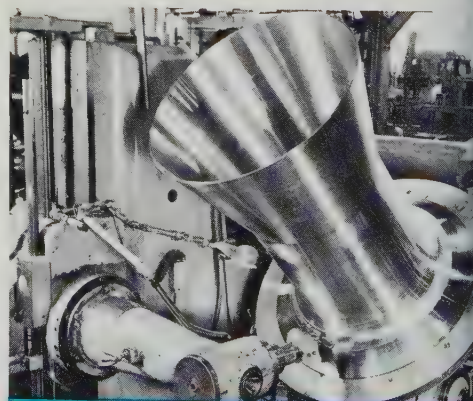
This 600-ton press at TAPCO is used to mold large exit cones for solid propellant rocket nozzles.



Winding glass fiber filaments over mandrel at TAPCO to form the shell for a reinforced plastic rocket chamber.



Special heat-resistant reinforced plastic would withstand expansion cone being cured in autoclave. TAPCO's autoclave is 14' long - 34" in diameter.



This 30" diameter by 45" long alloy steel nozzle is machined to within .002 of mean contour.

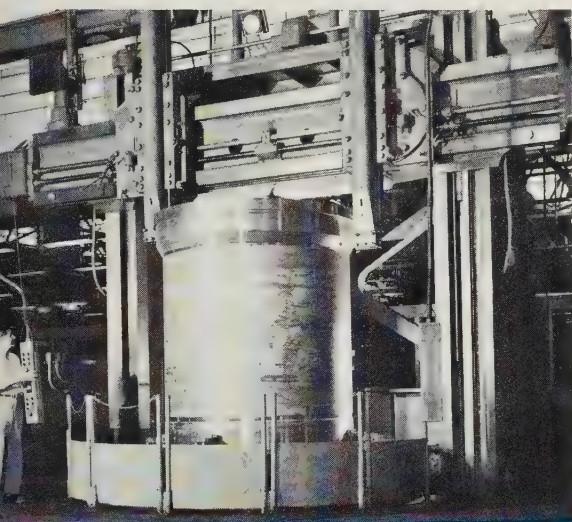
these few examples of TAPCO facilities and products give you
impression that

TAPCO can design...

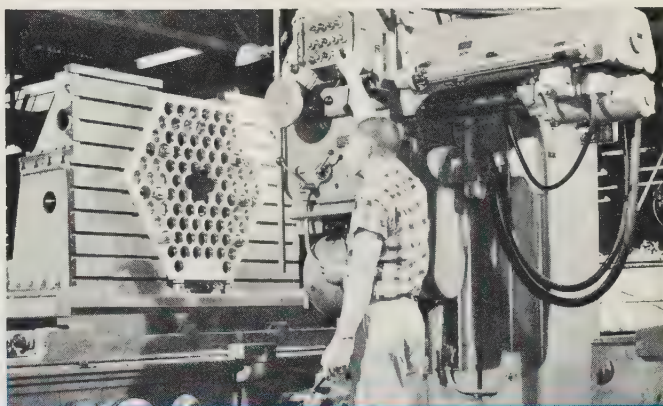
TAPCO can build...

TAPCO is equipped in its 400,000-square-foot structures
manufacturing area to produce, test, and deliver
many different kinds of components, assemblies,
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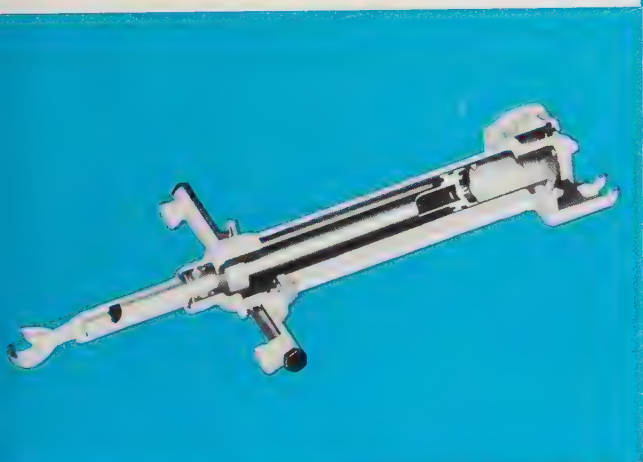
GOOD! We'll welcome your inquiry telling us when to see you.



This nuclear core structural component demonstrates TAPCO's capability to machine pistons up to 12' in diameter by 10' in height.



Basket segments and bottom core plates for nuclear reactors are machined and precision checked on special equipment at TAPCO.



Flotrusion and Metal Gathering processes are used at TAPCO to achieve good strength-to-weight ratios for many types of tubular members, such as the one-piece piston head and shaft in this TAPCO produced hydraulic actuator.



Titanium alloy rocket motor cases 20" in diameter machined from forgings, welded by shielded arc method, and heat treated by the TAPCO Group provide high strength-to-weight ratio. TAPCO has equipment to produce cases of various sizes and configurations.



TAPCO GROUP
Thompson Ramo Wooldridge Inc.

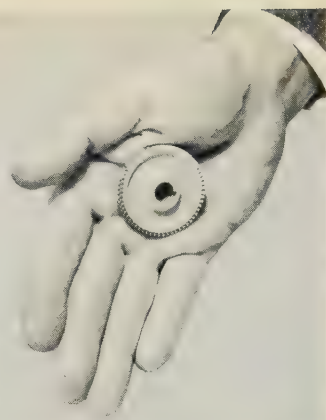
CLEVELAND 17, OHIO

DESIGNERS AND MANUFACTURERS OF SYSTEMS, SUBSYSTEMS
AND COMPONENTS FOR THE AIRCRAFT, MISSILE, ORDNANCE,
ELECTRONIC, AND NUCLEAR INDUSTRIES

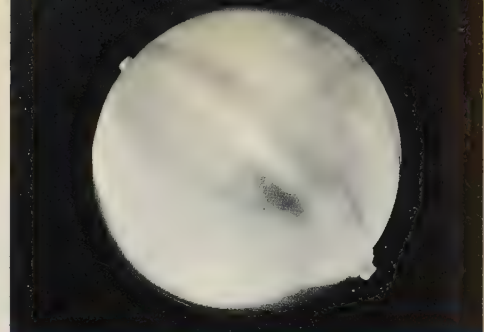
For some customers, TAPCO produces new structures and "hardware" from orthodox materials by new methods...

For others, TAPCO develops new materials, new techniques, new design theories...

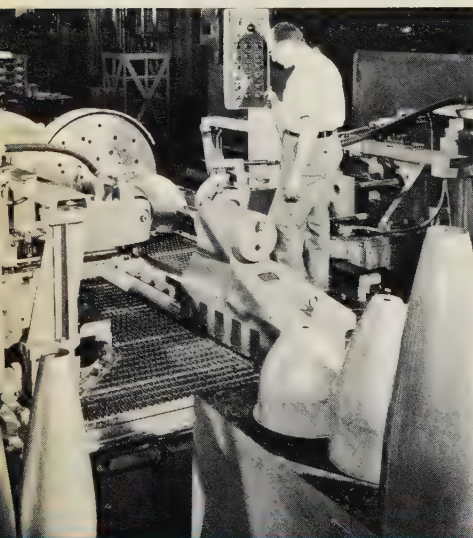
For both groups, TAPCO functions as an integral part of the customer's organization. When would you like us to call on you?



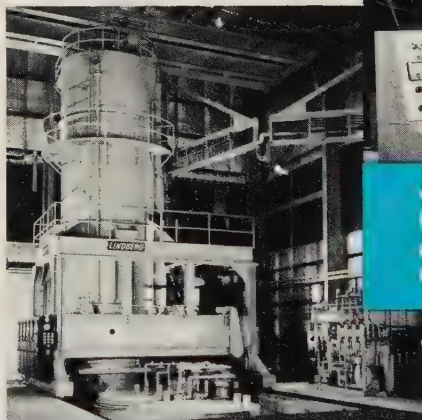
This "precision made" turbine wheel only 1½" in diameter was designed and produced from Columbium alloy by TAPCO for a miniaturized self-contained solid fueled power plant which weighs less than 4 lbs.



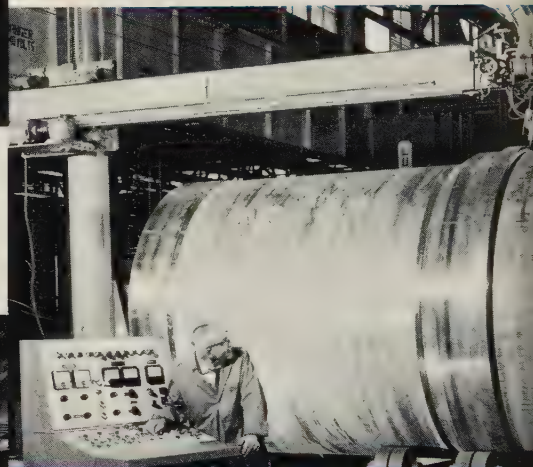
Capable of containing gases under high pressures at low temperatures, this Titanium spherical vessel was formed, welded, heat treated, and pressure tested under the direction of TAPCO development engineers.



Spine-shaped steel pipe is an example of what can be spun on TAPCO wheel spinning machines.



Pieces as large as 6' in diameter and 22' long can be heat treated by TAPCO in this new Lindberg controlled-atmosphere furnace.



Advanced techniques and the latest equipment for submerged and gas-shielded arc welding permit easy fabrication of components such as this 10-ton nuclear core barrel.

There are openings at TAPCO for qualified engineering personnel. Write to Technical Placement Manager.



TAPCO GROUP

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DESIGNERS AND MANUFACTURERS OF SYSTEMS, SUBSYSTEMS AND COMPONENTS FOR THE AIRCRAFT, MISSILE, ORDNANCE, ELECTRONIC, AND NUCLEAR INDUSTRIES



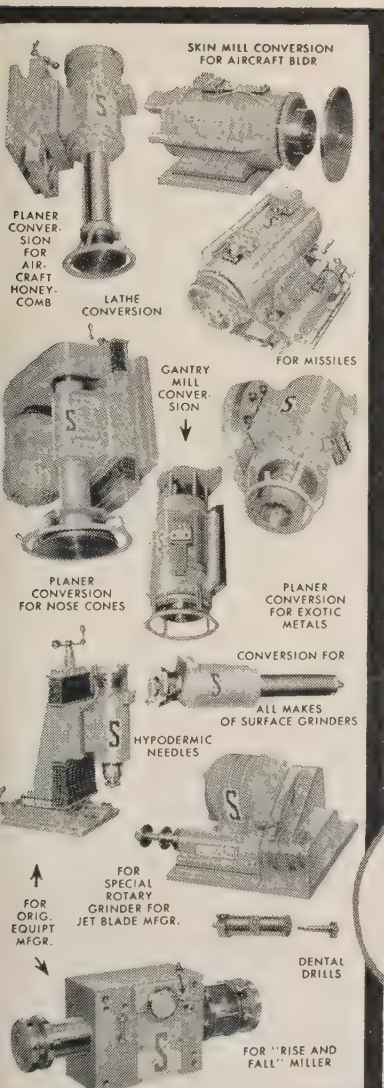
Quick-opening actuator-operated roof structure mechanisms for Bomarc Model II missile shelters at Eglin and Suffolk County Air Force Bases were designed and produced by the TAPCO Group.

ty. Its engines are GE T58s.

Sikorsky's *HSS* anti-sub copter has been operational for several years and is being replaced by the *HSS-1N*. Both copters are single-engine designs powered by C-W R 1820. The -1N has an automatic hover coupler and other features that permit it to operate in instrument weather.

Kaman, at BuAer's request, has made a proposal for the *ASK*, an anti-sub version of its HU2K-1, a T58-powered utility design.

Several other helicopters are being considered for ASW operations as part of the Navy's Dash (destroyer-and-anti-submarine-helicopter) program. Navy officials believe the 300 destroyers in service can be quickly modified to serve as copter bases for ASW operations. Among the helicopters used in Dash studies have been Republic's *Alouette II* jet, and Kaman's remotely control *HTK*. The Navy is conducting research on Dash using a Gyrodyne *DSN-1*.



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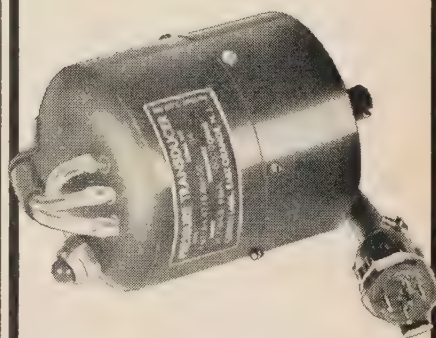
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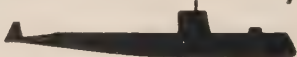
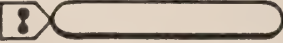
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January 1960

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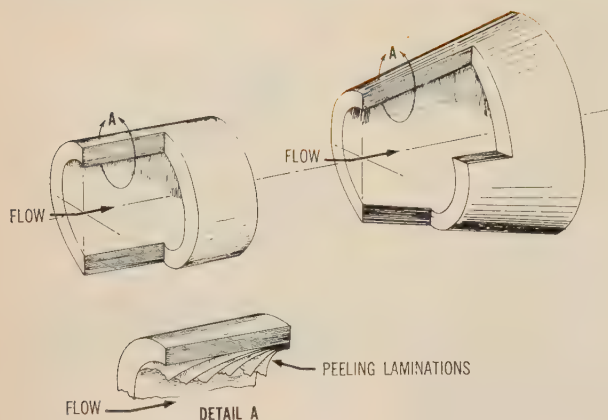


FIGURE 1: Parallel-grain design isn't good for ablation conditions, since the plies of the silica-phenolic peel off when exposed to high speed flow (once the bond between them has been destroyed).

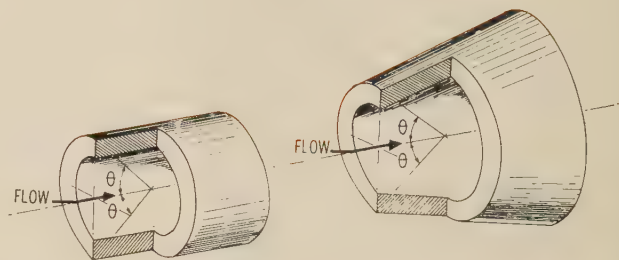


FIGURE 2: Angled-end-grain design is recommended for most rocket engine ablation applications of silica-phenolic laminate. The orientation angle (θ) of the grain must not exceed 90 deg in such applications.

New design approaches needed for silica-phenolic ablation materials

Not surprisingly, parts made for ablation during high temperature use call for fairly new design techniques. Here is a report that shows in detail how these techniques affect the design engineer in the case of silica-phenolic plastics, one of the proven ablation materials.

by **C. S. Brown**, Assistant Executive Field Engineer, H. I. Thompson Fiber Glass Co.*

SILICA-PHENOLIC PLASTIC is one of the few materials that has performed successfully at the extreme temperatures of re-entry nose cones and advanced rocket components. To show what can be done with such a plastic, let's take the case of Astrolite, a combination of virtually pure vitreous silica fibers and a resin binder system developed by H. I. Thompson Fiber Glass Co. (Hitco).

The silica fibers used in Astrolite were developed by Hitco under the trade name Refrasil, which stands for "refractory silica." They can be made in the form of cloth, batt, tape, sleeving, cordage, and yarn. Refrasil fabric is impregnated by coaters and later fabricated into Astrolite components.

Although the high temperature resin binder carbonizes at about 500 deg F, Refrasil's melting point is over 3000 deg F. On melting, the viscosity of the Refrasil is extremely high, so that the material is not easily blown away. Also, the melted Refrasil vaporizes.

* H. I. Thompson Fiber Glass Co., 1733 Cordova St., Los Angeles, Calif.

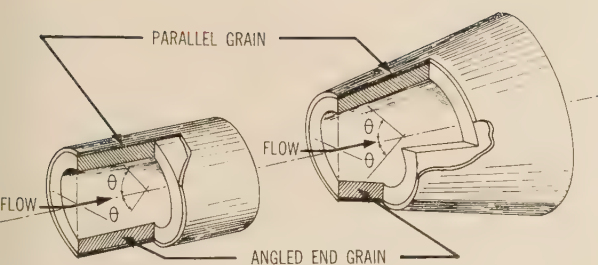
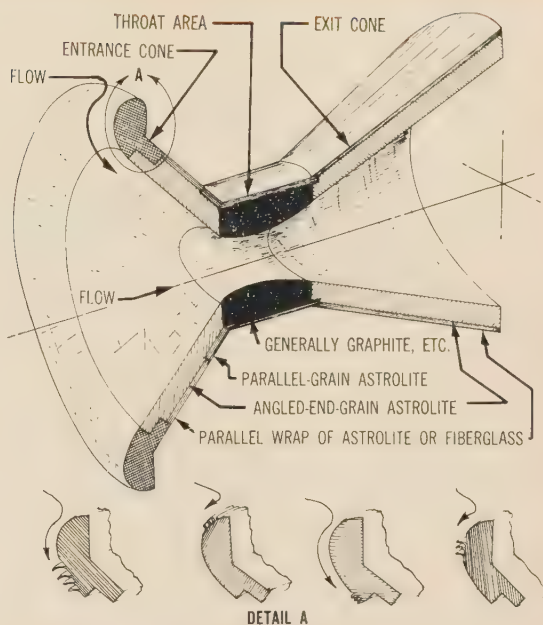


FIGURE 3: Composite structure (above) of angled-end and parallel-grain silica-phenolic. Right: Composite nozzle assembly uses molded and chopped pre-impregnated material at the entrance cone.



his effect tends to cool the surface of the material and lowers the erosion rate.

Another favorable factor is that Astrolite has excellent thermal shock properties during sudden, extreme temperature changes. The continuous-filament refrasil textiles have shown physical properties better than those of short-fiber refractory materials.

Fiber orientation of the reinforcement is the key to the success of most Astrolite applications. When erosion at high temperature is a problem, for instance, mechanical sloughing-off of material can be minimized by orientating the fibers at a certain angle to the direction of flow. Astrolite fabricated into this "end-grain" construction provides long, continuous silica filaments, each eroding at one end but firmly anchored to a cold portion of the part.

When mechanical properties and/or shape require, molded parts of chopped, pre-impregnated material may be used. In many applications, high density (over 100 lb/cu ft) parts must be made; failure to do so usually results in poor performance or even equipment malfunction.

The significance of fiber orientation for rocket engine parts can probably best be explained diagrammatically. Figure 1 shows a parallel-grain cloth construction on a tube and on a cone. Parallel grain is made by laying up cloth with the plies parallel to the surface of the part. High temperatures destroy the bond between plies, and at high speeds the plies then peel off. This obviously isn't good for ablation conditions.

Figure 2 shows angled end-grain for a tube and cone. The plies are laid up at some angle to the center-line of the part. This orientation angle θ is the angle between the plane of the plies and the upstream side of the flow axis.

This design is recommended for most rocket engine ablation bodies so long as θ does not exceed 90 deg. Usually an angle between 20 and 90 deg is specified;

more on next page

Physical Properties of Astrolite

Specific heat (approx. 30% resin content, room temperature to 500 deg F)	0.3 btu/lb/deg F	
Specific heat of Refrasil reinforcement		
Room temperature	0.19 btu/lb/deg F	
500 deg F	0.21 btu/lb/deg F	
1000 deg F	0.23 btu/lb/deg F	
1500 deg F	0.25 btu/lb/deg F	
2000 deg F	0.26 btu/lb/deg F	
2500 deg F	0.27 btu/lb/deg F	
3000 deg F	0.28 btu/lb/deg F	
Max. continuous service operating temperature	500 deg F	
Heat of fusion of Refrasil	102 btu/lb	
Temperature of appreciable Refrasil vaporization	3100 deg F	
Coefficient of linear thermal expansion (determined between 100 and 350 deg F)		
Parallel to laminations	0.22×10^{-5} in./in./deg F	
Perpendicular to laminations	1.06×10^{-5} in./in./deg F	
Emissivity	approx. 0.85	
Typical properties of Astrolite parallel laminates press-molded to over 100 lbs/ft ³		
	Room Temperature	1/2-hr Exposure @ 500 Deg F, Test @ 500 Deg F
Flexural strength (psi)	27,000	19,000
Flexural modulus (psi)	2.7×10^6	
Compressive strength (edgewise, psi)	27,000	20,000
Tensile strength (psi)	20,000	
Izod impact (ft-lb/in.)	97	
Water absorption (2-hr boil, per cent)		0.25
Barcol hardness		75

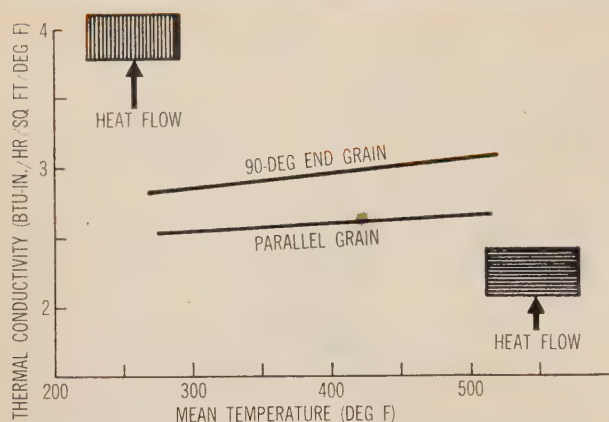
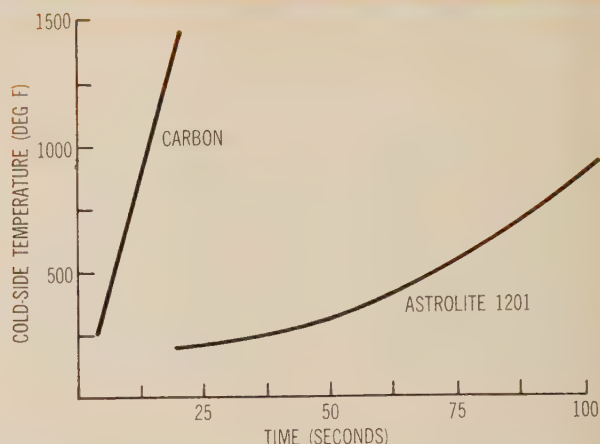


FIGURE 4: Thermal conductivities for two fiber orientations of Astrolite. The end grain has about 10 per cent more conductivity.



COLD-SIDE temperature vs time for Astrolite and carbon at 4500 deg F hot-side temperature, Mach 0.5 gas velocity, and 0.5 in. sample thickness.

on conical shapes, though, zero degrees is sometimes used.

Figure 3 shows a combination of parallel-and angled-end-grain construction. The parallel wrap is applied over the angled end grain to provide strength and added insulation.

Variety of orientations may be used

Figure 3 also shows the use of molded and chopped pre-impregnated material in a typical nozzle configuration. Because of its shape and ablation conditions, the forward end of the entrance cone is molded to provide random fiber orientation. We can see that laminates can't be used in this area, regardless of orientation angle. The parallel-grain section around the outside of the throat serves as thermal insulation. It is used instead of end-grain construction because in this area no ablation takes place. Critical portions of the entrance and exit cones use a combination of end-and parallel-grain construction.

Quite often, shape and/or extremely thin cross-sections require a part made from chopped Astrolite instead of either end-or parallel-grain material. Attempts at machining such material could lead to breakage or delamination.

Parts must be made with as nearly uniform density as possible. Pressure must be so applied that compaction is achieved without distortion of the fiber orientation.

Density depends on many factors—resin content, degree of advancement, shape of the part, etc.—but primarily it's controlled by the method of obtaining pressure during curing. All of the regular curing methods are used. Vacuum-bag curing will give densities of about 80-95; autoclave curing, about 90-105; and press curing, about 100-115 lb/cu ft.

For most missile components requiring ablation-resistant material, the material is more expensive than the labor needed for fabrication. As a result, many new fabrication methods, designed to use a minimum of material, have been developed. Tape winding seems to

offer the best promise for reducing waste material. Hitco's new Astro-Tape process, for instance, generally produces parts ranging from 90 to 110 lb/cu ft in density.

Among other new methods designed to improve the fabricability of ablation components, "profile orientation" shows great promise in providing end-grain surfaces for aft closures and entrance cones for which gas-flow conditions previously required the use of molding compounds. Another recent development is "spherical end grain," which provided fiber bundles with orientations emanating from an approximate common center and radiating outward to a hemispherical nose surface.

Resin content is primarily controlled to the customer's spec by the impregnator when he applied the resin to the fibers. Applied to C-100-28 or C-100-48 Refrasil cloth, this content, generally will range from 25 to 40 per cent solids (by weight). The tolerance on these percentages varies slightly between impregnators; to some degree it depends on the price the end user is willing to pay, but generally it is held to ± 3 -5 per cent.

Resin content also depends to some extent on the molding process. For example, a closed mold tends to retain resin, while an open one lets resin escape the boundaries of the finished part. The degree of advancement of the prepreg also influences the final resin content of the part since it determines the amount of flow. The curing cycle, too, affects the resin content.

There are two schools of thought when it comes to post-curing. One bases itself on the standard theory of structural fiber glass-phenolic laminates, according to which post-curing improves the high temperature strength by further curing and driving off excess volatiles. However, the energy absorbed in this driving-off process could, if retained, prove beneficial in the ablation process.

We know that post-curing oxidizes the resin before the actual use of the component. Reports from some users indicate that post-curing does not improve thermal shock or erosion performance of Astrolite in ablation applications. Sometimes post-cures are used to prevent

cracking of the laminate during subsequent bonding. At any rate, it's clear that much more work is needed before the value of post-curing is definitely determined.

Machining of Astrolite can be done on either post-cured or non-post-cured parts. Diamond-tipped bits, saws, and grinding wheels are preferred, since they need no coolant, no localized overheating of the part occurs, minimum tool pressure can be used (to minimize delamination), a better surface finish results, parts can be machined faster (because of quicker material removal), and machining costs are lower (because of lower tool wear). Whenever possible, both work and grinding wheel should be rotated. Carbide tools may also be used, but in this case the part should be flooded with water or some other greaseless coolant (to minimize overheating), extreme care must be taken to control cutting speeds and tool pressures when a coolant can't be used, and cutting edges must be kept sharp to minimize delaminations and avoid tolerance problems).

Drills should be made of carbide and be sharpened nearly flat—not more than 10 deg back from point of drill (160 deg included angle). They should be run dry with a coarse feed, and dust should be removed frequently.

Conventional inserts should be used whenever a threaded hole is required. Holes for inserts should preferably be perpendicular to the laminations, with the centerline of each hole at least two diameters from the edge of the part. All holes should be drilled deep enough to prevent bottoming.

Tag checks can be misleading

Testing for resin content, density, and remaining volatiles presents some problems. Resin content is found by destroying either the part or a tag or trim end by burning the resin completely out of the material. Destroying the part is the most accurate method, but hardly the best. Checking a tag or trim can be misleading, since it's possible for the resin content to be slightly higher in the outer edges of a part as a result of resin flow during curing. Because there are tolerances in both materials and processes, the tolerances on resin content should not be specified closer than ± 5 per cent. The method used to determine this content should be spelled out so that both the molder and his customer will test in the same manner.

Density is measured by weighing the entire part and calculating its volume. This, of course, does not assure uniform density throughout the part. For example, a cylindrical end-grain part that has had pressure applied endwise may actually have a higher density near the ends than near the center. Whether it does can't be determined without destroying it. Density tolerances should be ± 10 lb/cu ft for practical economical purposes; if absolutely necessary, it can be held to ± 5 lb/cu ft.

Engineers with little experience with plastics sometimes try to define parts with specs applicable to metal but not to plastic laminated parts. For instance, a drawing may require a plastic part to have a 63-micro finish surface. Usually there's a note on the drawing telling out the method of measurement in accordance with Mil-STD-10. This spec was written for the checking of surface conditions on metallic materials, which are homogeneous. When a surface roughness analyzer probe is passed over a metal surface, the variations in

readings represent real mechanical differences on the surface.

With reinforced plastics, the problem is considerably different. For instance, Astrolite isn't a homogeneous material—it contains Refrasil, which is relatively soft, and a resin, which is relatively hard. When the analyzer probe is passed over it, the readings will vary greatly, since the probe passes over hard and soft spots.

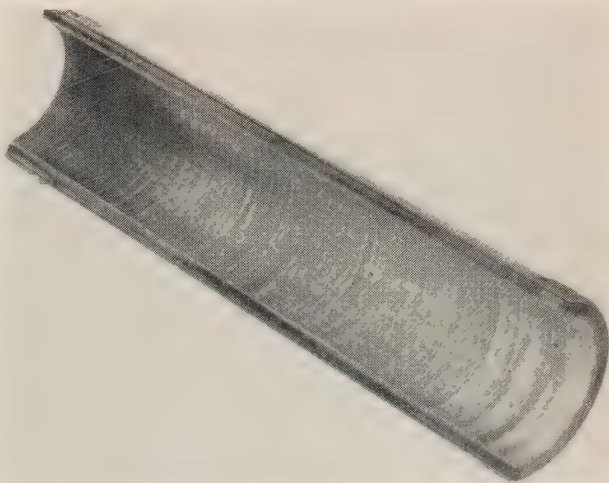
To compound the problem, machined plastic surfaces also have mechanical peaks and valleys. Coming on top of the hard and soft spots, these give very high readings. When you feel the surface, you will realize that it can't be as rough as the analyzer probe readings would make you believe. Several firms are trying to develop surface roughness measuring equipment to overcome this difficulty.

Many firms working on test methods

Many firms also are working on methods of non-destructive testing of Astrolite parts, including X-ray and ultrasonic processes. To date, though, no methods have proved completely satisfactory.

Figure 4 compares the thermal conductivities of 90-deg end grain and parallel grain. The end grain has about 10 per cent more conductivity. The values in Figure 4 are much higher than most of those given in the literature for comparable fiber glass-phenolic laminates because nearly all previous tests have been run on thin specimens (usually $\frac{1}{4}$ in. thick or less). The effect of the air films adjacent to the thinner specimens is appreciable, giving lower values apparent thermal conductivities. We believe the results shown in Figure 4 are realistic, since they were obtained by testing one-inch-thick specimens under conditions that eliminates the effect of air films.

The design engineer at present generally must test each new ablation laminate design to make sure he has a workable component—the day when enough detail data are available to allow handbook-type designing is still to come. The designer also should consult a reliable fabricator, so that the part as finally designed will be producible and make the best use of the inherent properties of ablation materials.—End



SECTION of production-type rocket engine blast tube of end-grain-oriented Astrolite. The tube has been fired for 60 seconds at 4500 deg F. Depth of penetration of char and slight, uniform erosion show the design to be correct.

Designing the structure of a Mach 3 transport

For the structural designer the Mach 3 transport represents such a leap forward even from today's jetliners that he will be well advised if he extends his studies beyond the types of structures favored by tradition. This article gives an idea of the range of possibilities such an approach will lead him into and discusses some of the outstanding parameters of trisonic structures.

by **M. G. Childers**, Airplane Research & Development Engineer, California Div., Lockheed Aircraft Corp.*

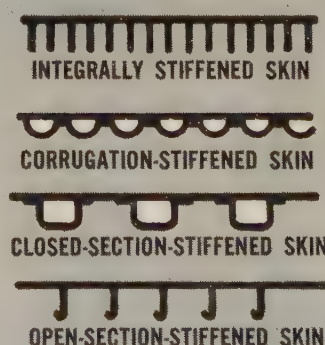
AMONG the material properties affecting the design of a Mach 3 transport, probably the most important is density. Except for beryllium, all the materials suitable for the 400-800-deg F temperature range of such a plane are denser than the traditional aluminum alloys (now ruled out because of low heat resistance).

To keep structural weight within economic limits, the new materials therefore must be used in thin gages and smaller cross-sectional areas. For designs in tension, this trend makes for problems when it becomes necessary to leave room for bolts, rivets, and other attachments, especially since these are of the same strength—and therefore size, too—as those used in the past for dural structure.

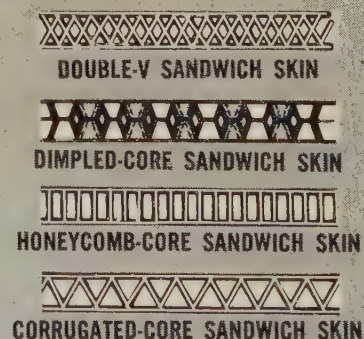
The high density materials will affect chiefly the portion of the structure which carries compression shear—normally 50-75 per cent of the total structure. To achieve maximum structural efficiency and a smooth

* California Div., Lockheed Aircraft Corp., Burbank, Calif. This is a condensation of a paper, "Preliminary Design Considerations for the Structure of a Trisonic Transport," given at the National Aeronautics Meeting of the Society of Automotive Engineers in Los Angeles, October.

BASIC configurations for surface and fuselage structures of a Mach 3 transport. For such a design, not only the structures favored by tradition should be considered but also those little used in the past. It can be shown that advanced configurations are not necessarily best in all applications.



SURFACE



aerodynamic surface, the designer must prevent buckling of the skin. At thinner gages, close support of the skin-stiffening elements is therefore required, as you can see from the classical formula:

$$(1) \quad F_{cr} = KE(t/b)^2,$$

where F_{cr} is buckling stress (in psi); K , fixity factor; E , modulus of elasticity (in psi); t , skin thickness (in inches); and b , distance between supports (in inches). Two different materials can support the same load per inch of material if:

$$(2) \quad F_{cr1}t_1 = F_{cr2}t_2.$$

The weight of the skin then is:

$$(3) \quad W_1 = t_1\sigma_1 \text{ psi}, \quad W_2 = t_2\sigma_2 \text{ psi},$$

where σ is density (in lb/cu in.).

By combining Equations 2 & 3 we get:

$$(4) \quad F_{cr1}/F_{cr2} = (W_2/\sigma_2)/(W_1/\sigma_1).$$

By combining Equations 1 & 4, we get:

$$(5) \quad b_1/b_2 = \sqrt{E_1/E_2} \sqrt{(W_1\sigma_2/W_2\sigma_1)^2}.$$

Figure 1 plots this equation with dural as the basis of comparison. We can see that, in terms of support structure spacing, titanium is superior to stainless steel, and beryllium is even better.

The Table also shows the effect of density by comparing the rib spacings and weights of integrally stiffened skins of dural, titanium, and stainless steel. As the number of supports increases, so does the complexity of the structure. As a result, it may prove difficult to keep down weight.

A very attractive method of reducing complexity and weight is to make the surface of some kind of sandwich. In this way, you increase the effective thickness of the surface structure without a corresponding increase in weight. Then you can space the internal structure more widely, which in turn cuts down on complexity.

The only trouble is that sandwich construction costs a lot, particularly for the materials suitable for supersonic transports. It's worth while, therefore, to consider also how much weight and complexity can be saved if a conventional stiffened-skin structure is used.

Let us begin our comparison of structural configurations with the wing and consider three designs: skin-

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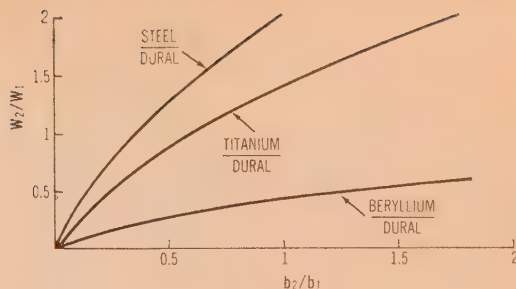


FIGURE 1: Skin support weight as a structural parameter, where W is weight and b is distance between supports, subscript 2 refers to dural and subscript 1 to the other material.

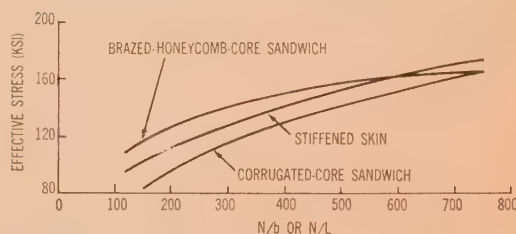


FIGURE 2: Effective allowable compressive stress at room temperature for PH 15-7 Mo RH 950, where N is load per inch; b , beam spacing; and L , rib spacing. At higher temperatures, the relationship of the three curves to each other remains the same.

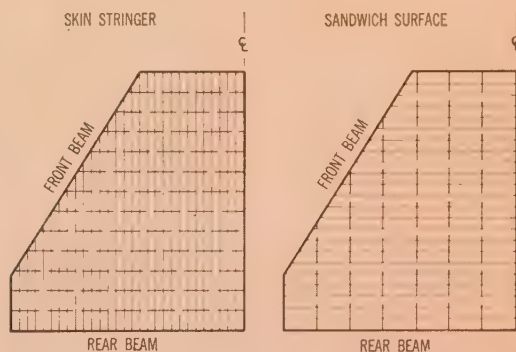


FIGURE 3: The two basic configurations to be considered for the internal wing structure.



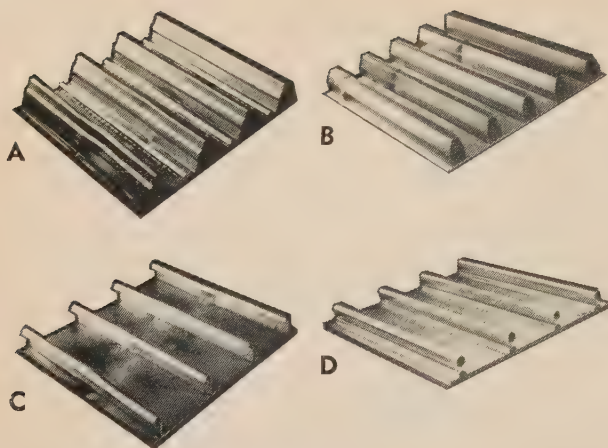


FIGURE 4: Panels of AM 350 (A, B, C) and extra-full-hard 301 (D) after testing at room temperature (A and C) and from room temperature to 600 deg F (B and D). Panel D represents an attempt to combine some of the advantages of sandwich construction and of stiffened skin; so far, it has not tested well. Both of the panels tested to 600 deg F showed strong (but calculable) effects from the thermal stresses due to the temperature gradient between skin and stiffeners.

stringer multi-rib and brazed-honeycomb-core and corrugated-core sandwich multi-beam. What allowable stresses can we achieve? The answer depends on the type of surface structure, the rib or beam spacing, and the temperature of the material. (The effects of temperature gradients we'll consider part of the stress pattern in the structure.)

Stiffened skin can be competitive

We can compare allowable stresses by plotting the allowable effective stress against the load per inch divided by beam spacing (for sandwiches) or rib spacing (for stiffened skins). From the resulting theoretical curves (Fig. 2), we can deduce:

- It is possible to design a stiffened-skin surface structure that is competitive in weight with brazed-honeycomb sandwich structure. At the higher load in-

tensities, the rib spacing for a stiffened skin approaches the beam spacing of a honeycomb sandwich.

- The corrugated-core sandwich is the least efficient of the three configurations we are considering.

Figure 4 shows four "hand-built" panels tested by Lockheed in order to compare allowable stresses. Panel B, the best of the stiffened-skin panels, tested to 90 per cent of the theoretical value at room temperature in spite of local buckles due to failure of poor spot welds. These buckles, incidentally, did not cause a catastrophic failure of the panel.

On the basis of these tests, Lockheed concluded that the values of the allowable-stress curve for stiffened skin in Figure 2 can indeed be achieved. However, further tests are needed to determine the best stiffener design.

Careful trade-off for rigidity

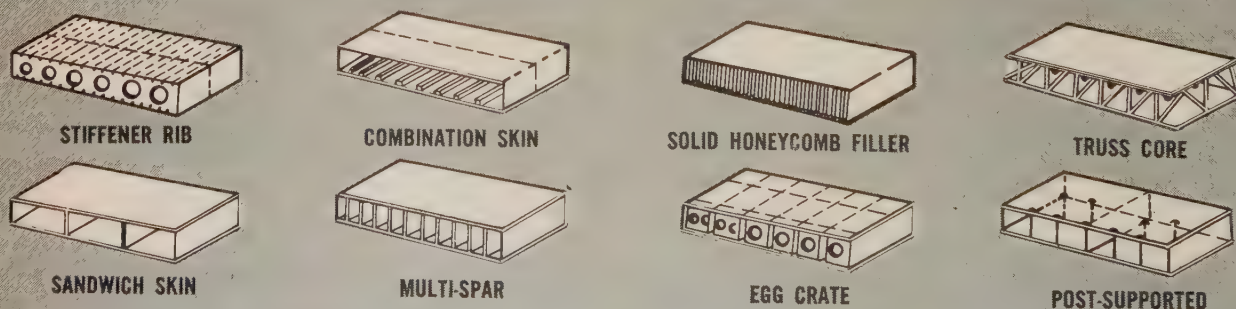
When we now turn to the requirements of structural rigidity, we face a tricky problem: The same parameters that affect the flexibility and dynamic characteristics of the structure in one sense also affect the aerodynamics of the airplane, but often in the opposite sense. A careful trade-off must therefore be made between the weight required for rigidity or to obtain satisfactory dynamic characteristics in some other way on the one hand and aerodynamic efficiency on the other hand.

Figure 5 shows the results of a study typical of the evaluation of this trade-off. It plots the effect of thickness ratio and aspect ratio on the weights required for strength alone and for adequate rigidity. It would appear that considerable weight can be expended to achieve rigidity. However, we must relate the information from Figure 5 to the overall system—as in Figure 6, which shows the effect of the thickness and aspect ratios on direct operating cost, taking into account both weight and aerodynamics.

There are also certain optimum distributions of a given amount of structural material that will yield the greatest rigidity. These distributions are best found with the help of a computer.

The choice of overall structure may also be influenced by the requirements of the internal structure supporting the surface and transmitting span- and chordwise shears. Two basic kinds of structure must be considered: the multi-beam type, which goes with the sandwich surface structure, and the multi-rib type, which goes with the

BASIC wing structures to be considered for Mach 3 transports.



stringer-skin surface. Because of the low aspect ratio of any Mach 3 wing, the multi-beam type actually requires some chordwise support to provide shear stiffness, while the multi-rib type requires a number of spanwise beams to reduce the shear lag effects.

Figure 3 shows the two basic internal types of structure. The multi-beam configuration has fewer parts and so may tend to be less complex. In a preliminary weight analysis at Lockheed, no significant difference appeared between the two structures once the weight was taken into account that is required for the attachment of the honeycomb surface to the substructure and to itself.

The razor-thin structure at the leading and trailing edges presents serious rigidity and space problems. Honeycomb cores between the top and bottom surfaces appear to be the best solution. However, as the wing thickness increases, a surface-to-surface core becomes heavy and other structural configurations now look more attractive. Among the possibilities are regular honeycomb-core sandwich, corrugated-core sandwich with the core running perpendicular to the leading or trailing edge, and skin corrugation or stiffeners.

Other problems of the internal structure that must be considered include:

- thermal stress alleviation, which requires internal structure (e.g., beams and ribs) flexible to thermal deflections and yet able to carry structural loads;
- surface smoothness, achieved by close spacing of stiffeners or suitable sandwich cores;
- thermal deflections, which can cause sizeable losses in allowables and rigidity;
- thermal conductivity into the wing interior (which is particularly important when cruise fuel is carried in the wing);
- the effect of long-life requirements on producibility and material and joint stability.

For the fuselage structure of a Mach 3 transport, many possibilities have been reviewed by Lockheed. In the end, it was decided that the main emphasis of further study should be placed on conventional configurations operating at the appropriate wall temperatures.

Many of the design considerations we have discussed in connection with the wing apply to the fuselage as well. In addition, the fuselage's cylindrical shape and the need for conditioning the passenger environment inside the fuselage raise special problems.

The fuselage was strength-critical

For the particular configuration studied by Lockheed, the fuselage is strength-critical, so a very careful choice had to be made between titanium and stainless steel. As Figure 1 shows, titanium saves considerable weight, but it also increases the cost. The cost penalty, however, is clearly less than the dollar value of the weight that is saved. A titanium fuselage structure therefore appears likely.

Such a structure probably would be a conventional, stiffened skin-ring type, with both stiffeners and rings spaced closely enough to prevent skin buckling. Brazed titanium honeycomb sandwich structures are still too unreliable and expensive to be considered. New developments, of course, could change this situation—if titanium honeycomb sandwich could be used, the weight saving would be even greater.

The ring depth must be considered in detail, and an analysis of fuselage shell stability is therefore necessary. Ring weight naturally must be minimized, but in addi-

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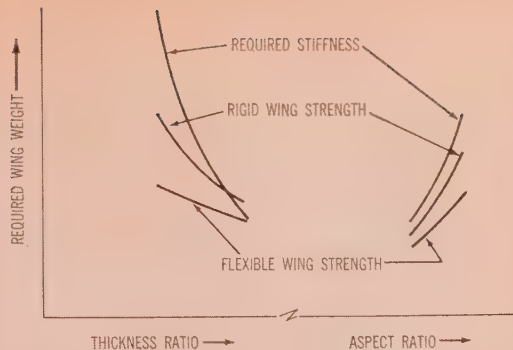


FIGURE 5: Effect of thickness ratio (at constant aspect ratio) and aspect ratio (at constant wing thickness) on the wing weight.

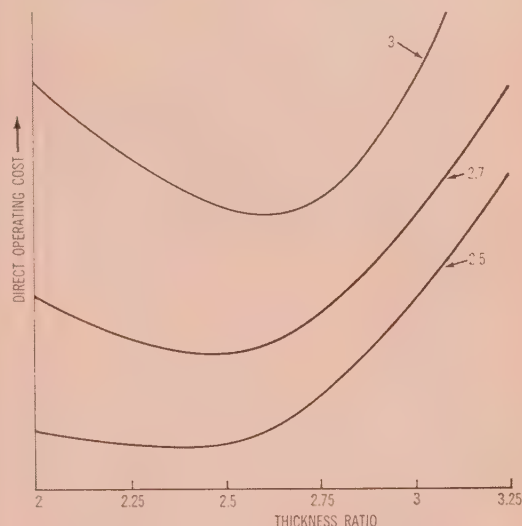
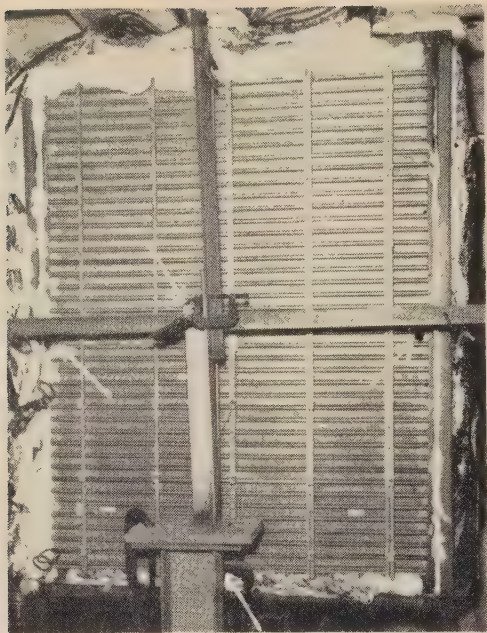


FIGURE 6: Effect of thickness ratio on direct operating cost at various aspect ratios.

Comparison of Integrally Stiffened Surfaces

	Dural	Titanium	Steel
Rib spacing at equal surface weight (in.)	20	11.9	6.6
Weight at equal rib spacing	1	1.3	1.75



TEST PANEL was evaluated by Lockheed in studies of the thermal deflection and temperature distribution in the fuselage shell structure.

tion there is the problem of the ring as a thermal short circuit through the insulation—the deeper the ring, the harder it becomes to prevent thermal leakage into the cabin cooling system.

As the design internal pressure is high, the structural designer would like to use it to help stabilize the fuselage shell. However, most of the shell is designed to ground or low altitude flight conditions, under which the pressure is either zero or very low.

Safeguards against fatigue cracks

The structural designer also must provide satisfactory fatigue crack resistance and forestall crack growth beyond safe limits. One way of dealing with this problem is to restrict the tension stresses in the fuselage that result from the pressure. In the process, of course, weight can become excessive, since material gages are available only in discrete increments (unless the more expensive tapered sheets are used).

Straps, bands, or frequent skin joints can also be used as crack retarders. The more closely spaced stiffeners and rings required for the structure will have a favorable effect on crack prevention, too.

Typical of other problems that strongly influence the detail structural design of the fuselage are thermal expansion and its effects on floor supports, interior trim and cooling panels, and the wing-fuselage intersection, and the transmission of heat through the structural joints.

Considerable effort has gone into studies comparing brazed-honeycomb-sandwich and stiffened-skin structures for a Mach 3 transport. One of the reasons why in our discussion here we have been emphasizing the more conventional stiffened-skin designs is that, if a Mach 3 transport had to be built today, stiffened-skin structures would lend themselves more readily to in-plant fabrication with a minimum of new capital equip-

ment. Also, their development times would be shorter, and the whole airplane could be built more cheaply.

According to current estimates, brazed honeycomb sandwich would make the basic structure three times more expensive. It would therefore increase the transport's initial price by several million dollars.

Sandwich structures used anyway

Of course, in many places on a Mach 3 transport sandwich construction will be used in any event, either because no other structure could do the job or because exceptional advantages make up for high cost. As the price of sandwich construction comes down, these applications will increase, and a really cheap configuration undoubtedly would find wide use. Even in such a case, though, stiffened-skin structure still is likely to be used extensively in a Mach 3 transport. It would be competitive in weight and offer advantages for inspection and maintenance, an important consideration for airline service.

As we've noted, the use of titanium in place of stainless steel also raises costs. However, a good deal of weight is saved, too. In certain parts of the structure, for which the additional cost of titanium can be estimated as ranging between \$75 and \$100 per pound of weight saving, the use of titanium is justified—an economic analysis shows that, for a Mach 3 transport, the maximum allowable cost of one pound of weight saving is \$350. In fact, even if our estimate of the extra cost of titanium were off by a factor of 2, titanium would still be worth while.—End

REFERENCES—R. Goldin, "Design Criteria for Heated Aircraft Structures;" ASME Paper 56-AV-14, '56. M. Goldman, "Discussion on Safety Factor Requirements for Supersonic Aircraft Structures;" ASME Paper 56-AV-18, '56. A. T. Clemen, "High Temperature Flight Safety Factors;" 3rd Symp. on High-Speed Aerodynamics & Structures, San Diego, Calif., March '58. Goldin, "Thermal Creep Design Criteria;" IAS Nat. Summer Meet., Los Angeles, June '57. N. Mangurian, "The Aircraft Structural Factor of Safety;" Agard Report 154, ('57). N. S. Hoff (ed.), "High Temperature Effects in Aircraft Structures;" Pergamon, '58. "Symposium on Structures for Thermal Flight;" ASME, Los Angeles, '56. "Structural Design for Aerodynamic Heating;" WADC TR 55-305 ('55). B. E. Gatewood, "Thermal Stresses;" McGraw-Hill, '57. R. E. Hubka, "Effects of Physical Factors and Analytical Procedures on Predicted Temperatures and Thermal Stresses;" Lockheed-Calif., LR 12777 ('58). B. A. Boley & J. H. Weiner, "Thermal Stress Analysis for Aircraft Structures;" WADC TR 56-102 ('55). A. V. Levy, "Performance of Materials at Elevated Temperatures for Aircraft and Missile Applications;" Marquardt. J. E. Rhodes, "Comparison of Primary Structural Materials for Use at Elevated Temperatures;" Lockheed Report 10646. J. N. Barnett & W. W. Rhode, "Workhorses of the Industry": PH Stainless Steels;" AVIATION AGE R&D HANDBOOK, 2 ('58). R. J. Nekervis, C. H. Lund & A. M. Hall, "Status of High-Strength Steels for the Aircraft Industry;" Battelle TML 91 ('58). L. R. Jackson, "Material Properties for Design of Airframes Structures to Operate at High Temperatures;" Battelle TML 38 ('50). J. C. Ekvall, "Strength and Thermal Limitation of Materials for Airframe Components;" Southern Calif. Section, SAE, March '58. T. J. Stapleton, "Crack Propagation Tests on Several High Strength Steels;" Lockheed-Calif. LR 13207 ('59). "Strength of Metal Aircraft Elements;" Mil-HDBK-5 Coordination Copy. M. S. Anderson & R. G. Updegraff, "Some Research Results on Sandwich Structures;" NACA TN 4009 ('57). Anderson, "Local Instability of the Elements of a Truss-Core Sandwich Plate;" NACA TN 4292 ('58). "Engineering Status Report on Budd Integrated Core Panels;" Budd. "Buckling of Flat Sandwich Panels under Edgewise Compression or Shear Loading;" Lockheed-Ga. ER-3283. "Local Instability of Sandwich Construction under Various Types of Loading;" Lockheed-Ga. SMN 37. "Stress Memo Manual;" Lockheed-Calif. S. Timoshenko, "Theory of Elastic Stability." H. L. Hibbard & R. A. Bailey, "The Case for the Supersonic Transport;" IAS Paper 59-119.

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.2% Yield Strength, psi	150,000	125,000
.02% Yield Strength, psi	135,000	110,000
Elongation (% in 2")	15	18
Reduction in Area, %	18	20

STRESS RUPTURE:

	Combination Smooth and Notch Bar	Smooth Bar
Temperature, ° F	1350	1650
Stress, psi	85,000	25,000
Life, Hours	100	50
Elongation, %	12	12
Reduction in Area, %	14	14

Guaranteed Minimum Mechanical Properties

TENSILE PROPERTIES:

	Room Temp.	1400° F
Ultimate Strength, psi	180,000	135,000
.2% Yield Strength, psi	132,000	115,000
.02% Yield Strength, psi	120,000	100,000
Elongation (% in 2")	12	13
Reduction in Area, %	14	18

STRESS RUPTURE:

	Combination Smooth and Notch Bar	Smooth Bar
Temperature, ° F	1350	1650
Stress, psi	85,000	25,000
Life, Hours	40	25
Elongation, %	8	10
Reduction in Area, %	10	12

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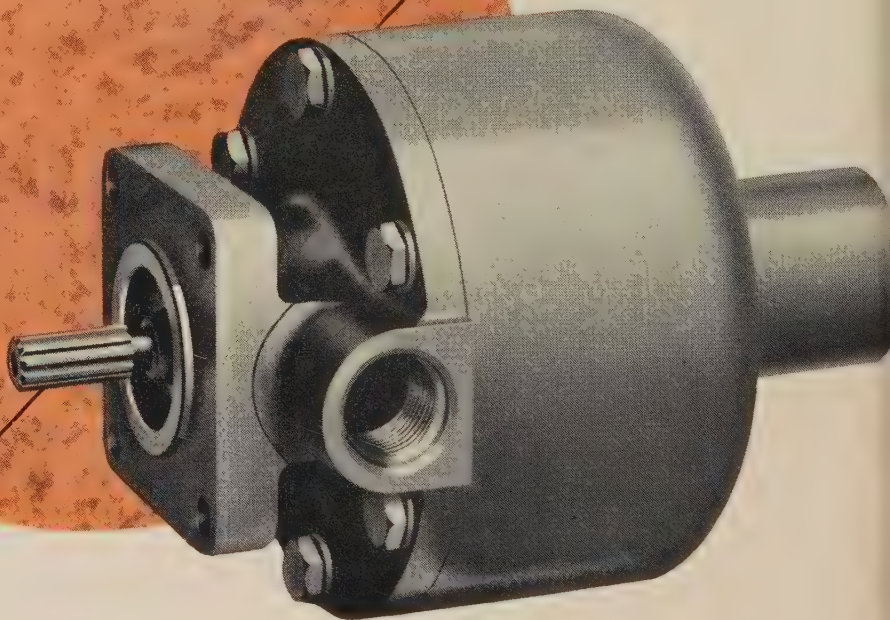
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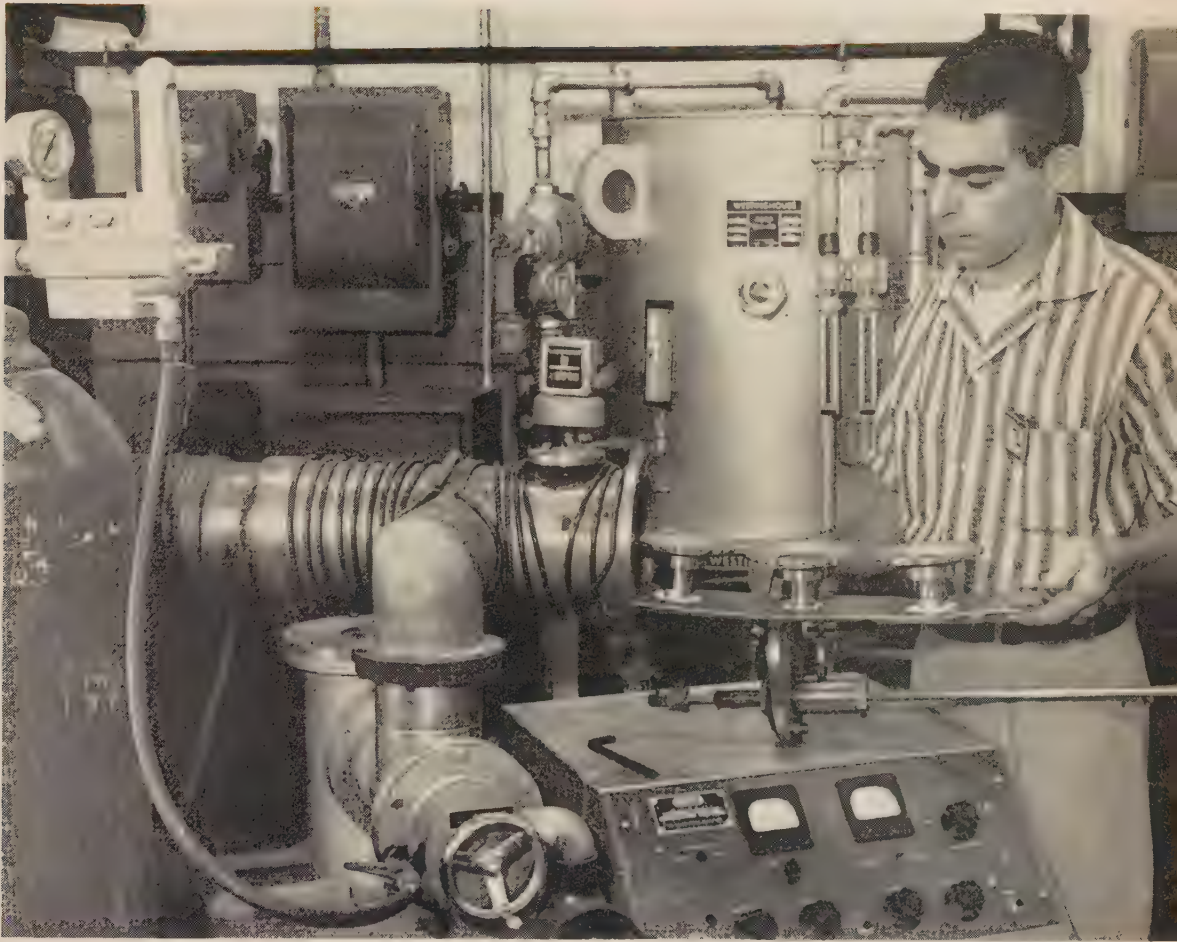


FIGURE 1: Typical vacuum-brazing installation at Westinghouse's Gas Turbine Div. Retort has $\frac{1}{4}$ -in. Inconel wall, six-inch OD.

How to braze in a vacuum

Vacuum-brazing shows promise of overcoming the problems of brazing limited runs of relatively small parts. Here are some pointers on the best techniques to follow with this new production method.

by **F. D. Seaman and E. M. Lundgren,**

Section Engineer & Laboratory Engineer, resp., Process Development Laboratory, Aviation Gas Turbine Div., Westinghouse Electric Corp.*

VACUUM-BRAZING is among the most versatile of the new joining methods. Its advantages include easy control, which cuts down on rejects, higher operating speed, particularly with small job lots (*Table 1*), and increased safety.

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* Aviation Gas Turbine Div., Westinghouse Electric Co., P.O. Box 288, Kansas City, Mo.

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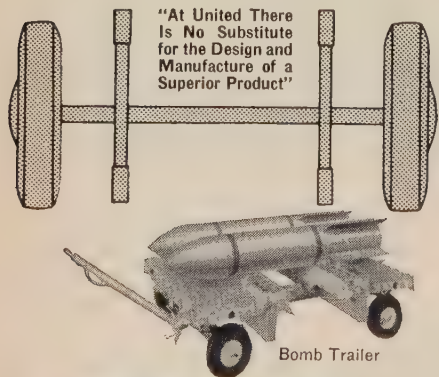
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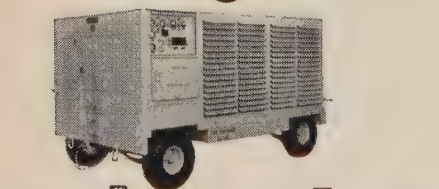
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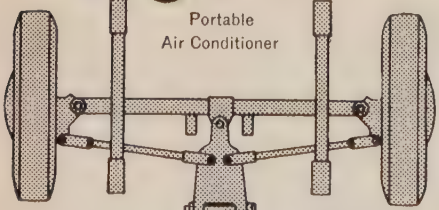


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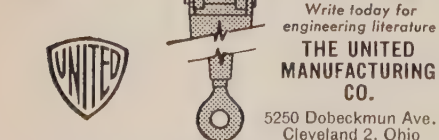
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VACUUM-BRAZING . . .

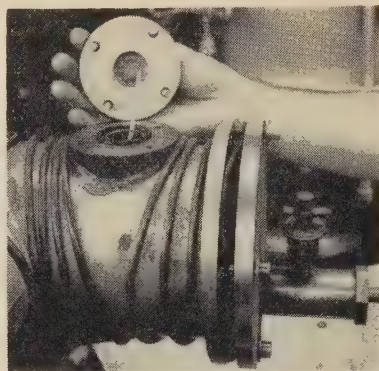


FIGURE 2: Typical sealing methods for metal retorts. Thermocouple wires are solder-sealed in small tubes with low-melting solders or brazing alloys. Only three bolts are needed to seat the charging port at right, since the seal is tightened as the pressure inside is reduced. Movable rod projecting from the port cover manipulates the charge in the furnace.

If the temperature is high enough and the pressure low enough, most surface compounds will dissociate. Unfortunately the necessary conditions can't always be achieved. Occasionally, low-melting metals like cadmium and zinc will evaporate right out of the brazing alloys at brazing temperatures. Alloys containing these metals therefore must be avoided.

Most of the problems in vacuum-brazing really are based on misunderstandings. You should be able to avoid them if you have some knowledge of the use of vacuums in fabrication and of basic vacuum apparatus.

As external pressures may reach 15 psi, a spherical shape is preferred for the container—it gives you the greatest strength. If a sphere is impractical, a dome or cylinder may be used. Angled shapes should be avoided.

Figure 1 shows a typical vacuum-brazing installation. The retort has a six-inch OD and a ¼-in. Inconel wall. It can be opened at any time without danger to the operator. The working zone is 18 in. long. Coils speed the cooling of parts under vacuum.

One way of making the container less critical is to use cold-wall construction—i.e., place the heating element inside. Heat is then transferred by radiation in the form of radiant energy, if the heat source is a resistance heater, or of electromagnetic energy, if an in-

Table 1: Speed of Operation for two Brazing Methods

	Time (min.)
Vacuum Brazing	
Pump down	5
Heat, braze and cool	60
Return to atmospheric pressure and open furnace	5
Total	70
Hydrogen Brazing	
Purge with inert gas	90
Fill with hydrogen	15
Heat, braze and cool	60
Purge with inert gas and open furnace	15
Total	180

*These figures are based on a small production furnace built to operate with either atmosphere or hydrogen. Many of today's complex alloys and assemblies can only be joined in a batch-type operation.

duction coil is used. With resistance heating elements, a reflector should be used to improve efficiency and shield the walls of the heavily loaded container.

Figure 3 shows an inexpensive and convenient glass-walled furnace operating at one micron. Glass is perfectly satisfactory in this case, because it transmits radiant energy without unduly heating up. A vacuum pump on the wall can be connected to a suitable retort in the small tube furnace.

Openings must be kept to a minimum

Openings that must be sealed should be reduced to a minimum.

Figure 2 shows typical sealing techniques for metal retorts. Don't use sealing materials that will evaporate in the vacuum.

All surfaces in a vacuum are covered by adsorbed gas films which may be rapidly released by evacuating and heating. Brazing powders, mesh, and flocculent porous refractories may cause trouble because of the relatively large volumes of gas they may evolve.

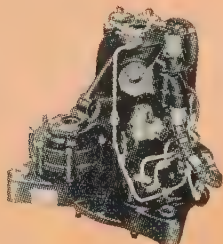
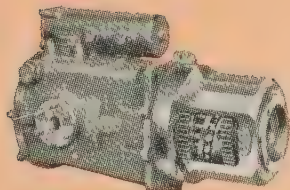
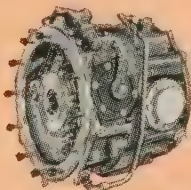
So long as a large number of gas molecules is present, gases can be pumped out of the furnace.

*A detailed description of good sealing practice and many other techniques can be found in S. Dushman, "Scientific Foundation of Vacuum Technique," J. Wiley, New York City.

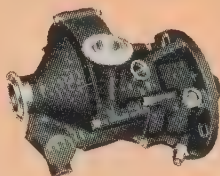
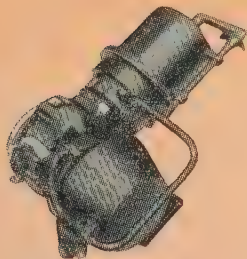
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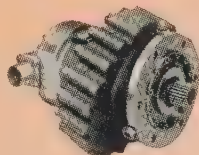
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VACUUM BRAZING . . .

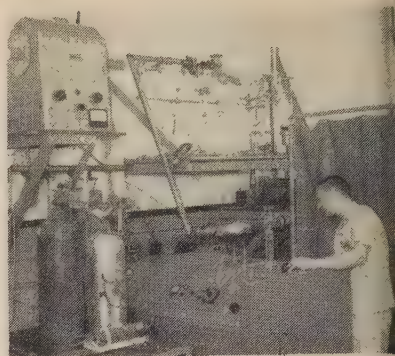


FIGURE 3: Inexpensive glass-walled retorts can be used for lab vacuum brazing tests.

mechanically. As the number of molecules in the furnace is reduced, the remaining molecules act like balloons floating in a large room, continually and haphazardly bounding off whatever surfaces they happen to strike. After each collision, they travel a certain straight-line distance, the so-called "mean free path," before striking another molecule or portion of the container (Table II).

A vapor diffusion pump is used

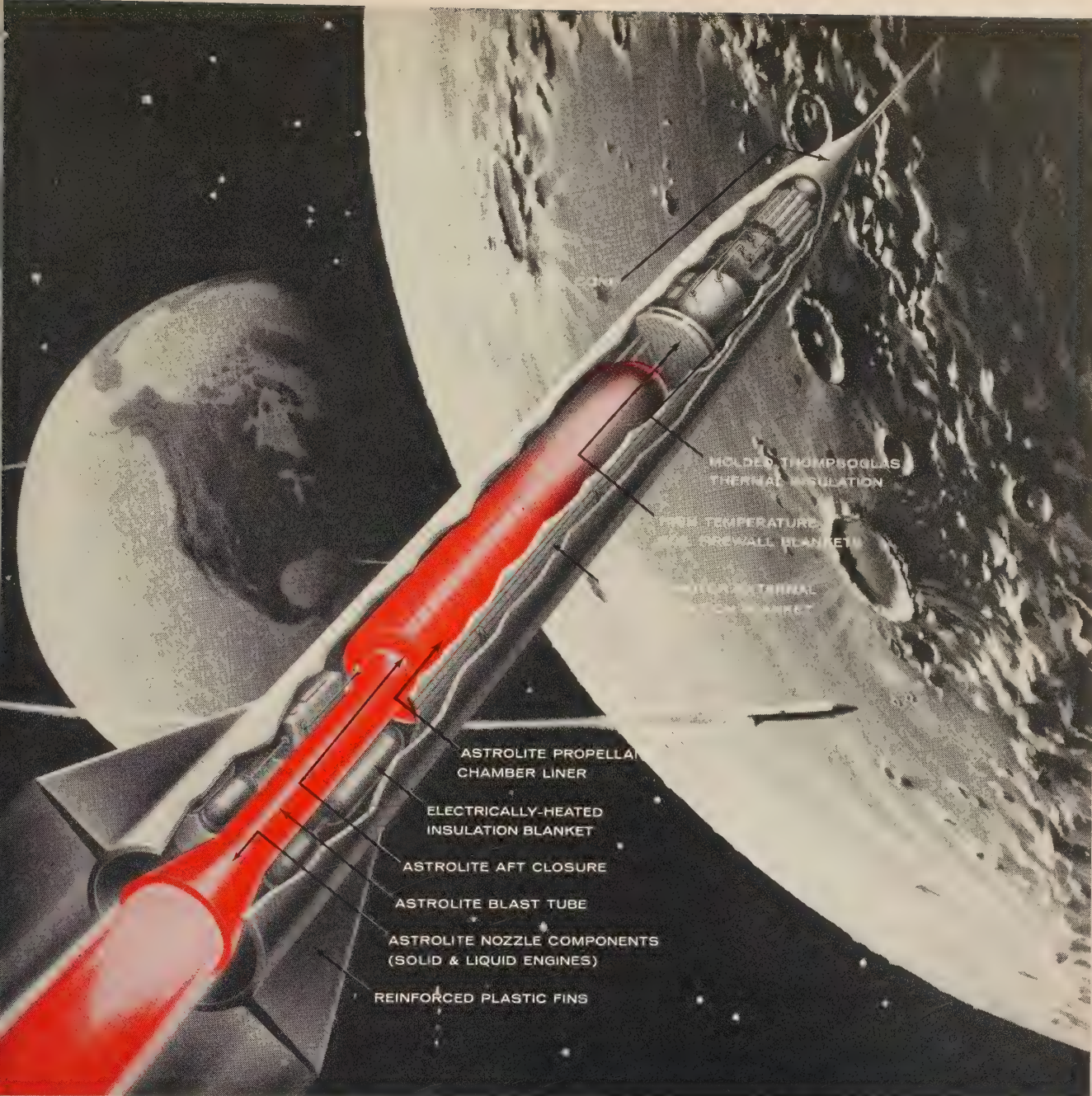
Most vacuum-brazing takes place under low-vacuum conditions. To handle gases effectively, the diameter of the line to the pump should be larger than the mean free path of the gas in question (which otherwise would collide with the walls). The lines from the retort to the pump should also be as straight and short as possible.

A special vapor-diffusion pump must be used to evacuate the few remaining molecules (Fig. 4). This pump mixes the gas with a jet of liquid vapors at its mouth and then moves this relatively dense mixture into a chamber in which the liquid is condensed away from the gas. The vapor stream coming into the upper section of the pump prevents any backward movement of the gas. The trapped gas is pumped away from the condensed liquid by a mechanical pump.

In the brazing region the pressure is 0.1-1 micron and few conventional pressure-measuring devices will register at all. The common mercury manometer can be adopted, however, in the form of the McLeod gauge.

For shop operation, though, more rugged devices must be used.

more on page 126



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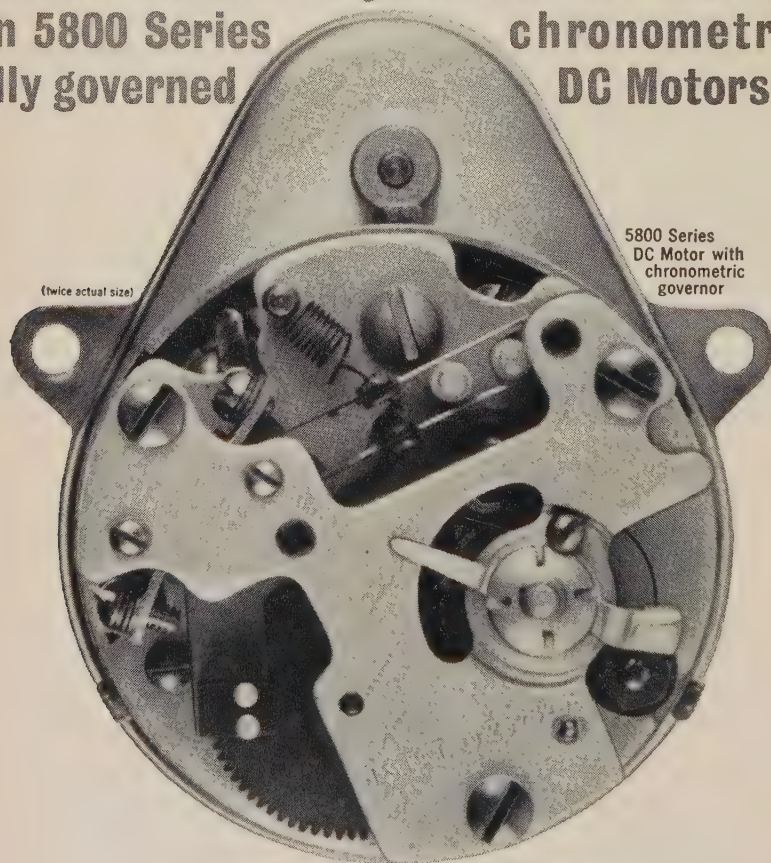
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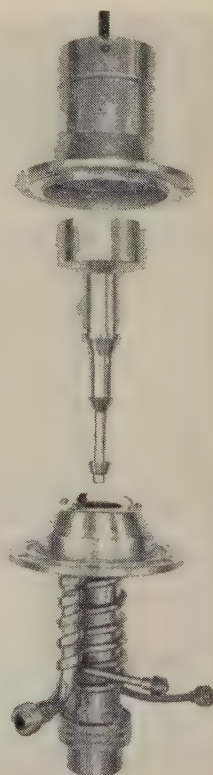
Table II: Mean Free Paths

Gas	Mean Free Path (cm)*
Air	5.09
Argon	5.31
Oxygen	5.4
Hydrogen	9.31
Helium—	14.72

*At 25 deg C and one micron Hg.

The thermocouple gage is used for the pressure range from one micron to one millimeter. It makes use of the low heating effect in a vacuum by measuring the temperature of a hot object through an intervening vacuum. The lower the pressure, the lower the apparent temperature as sensed by the thermocouple junction. A more complex apparatus, based on the principle of the vacuum tube, is the emission gage, which measures pressures over a range from 10^{-9} to 70 microns.—End

FIGURE 4: Disassembled vapor diffusion pump.



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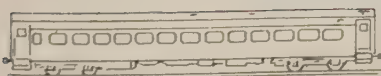
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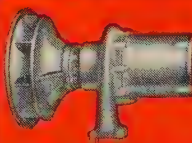
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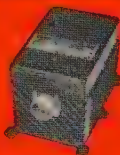
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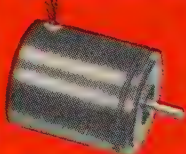
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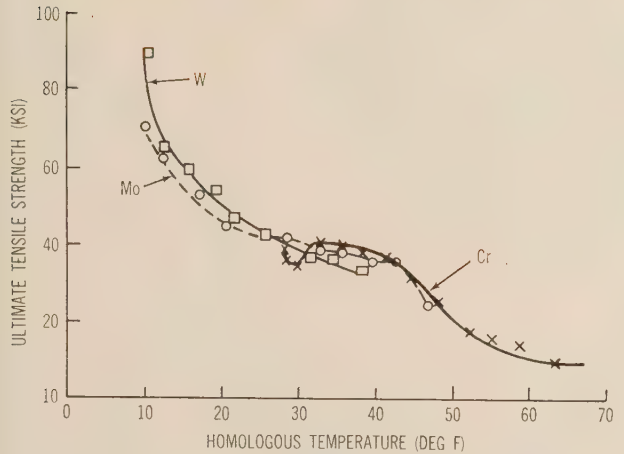
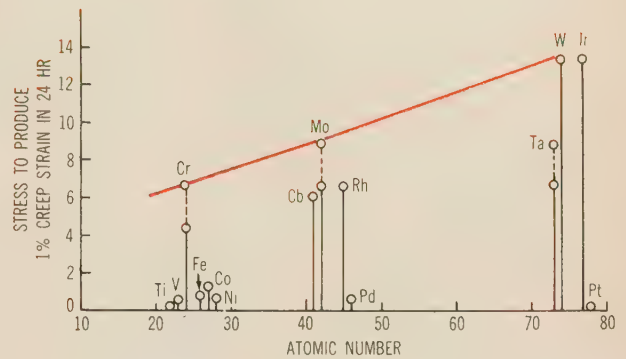


FIGURE 1: Strengths of three refractory metals vs homologous temperature (left), or percentage of absolute melting point (3360 deg F for chromium, 4550 deg F for



molybdenum, and 6170 deg F for tungsten). Right: Creep strength vs atomic number for some metals. Dashed lines indicate spread of data.

Which metals for high temperature structures?

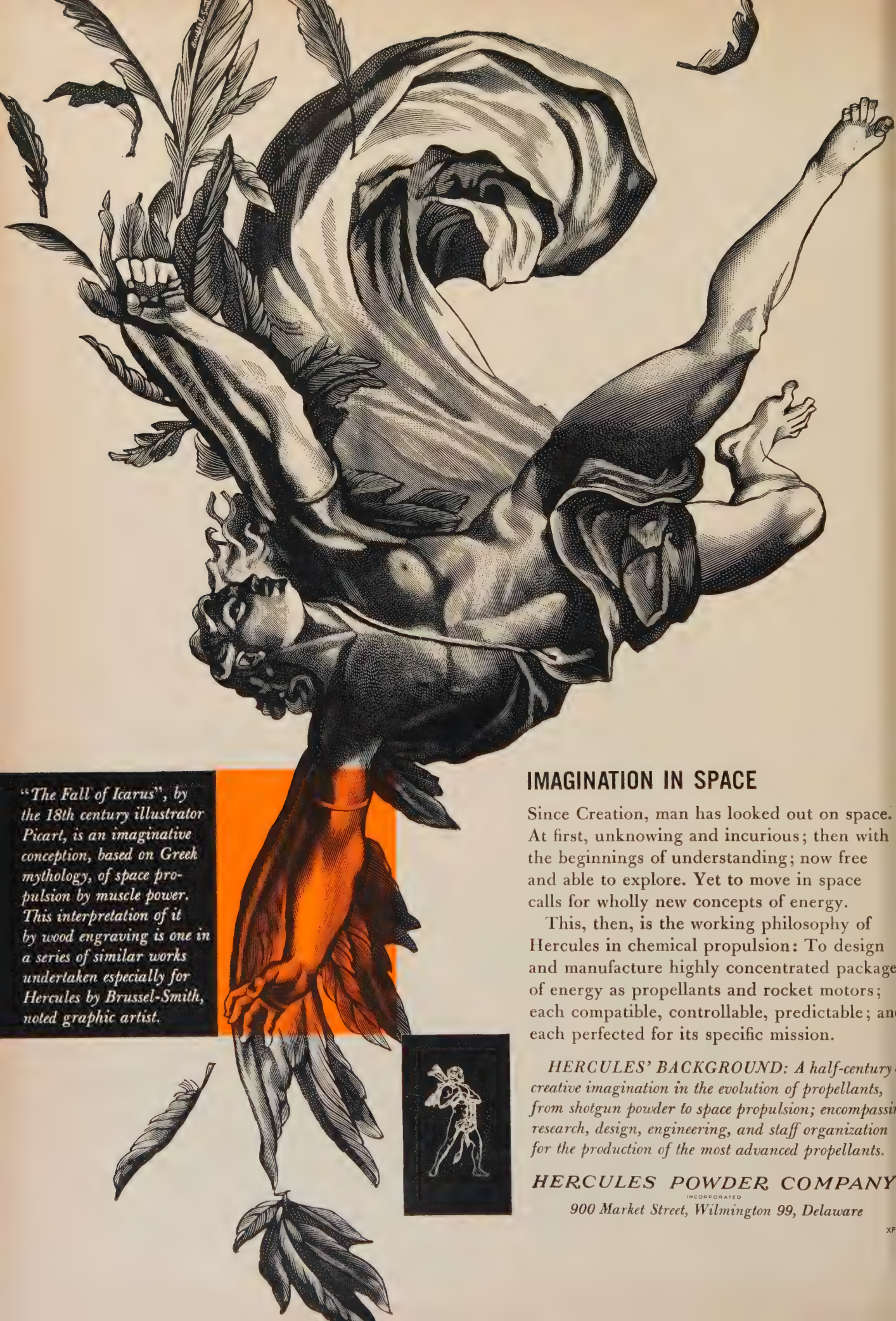
As the requirements of high temperature aerospace structures increase, so does the variety of metals and alloys suggested to meet them. This article sorts out the many promising metallic high temperature materials that have appeared recently and shows where and how they can best be used.

by **V. D. Barth and H. R. Ogden**, Metallurgical Engineer, Physical Metallurgy Div., & Consultant, Nonferrous Physical Metallurgy Div., Battelle Memorial Institute¹

HOW far can we go in our efforts to develop metals that will withstand the ever higher service temperatures of aerospace structures? For purely metallic materials, the melting point of tungsten at 6170 deg F can be taken as the upper limit. If we include refractory hard metal compounds among the metallic materials, the limit is raised slightly. For example, tantalum carbide melts only at about 6800 deg F and hafnium carbide at about 7000 deg F.

Below this temperature ceiling there is a broad range of metals, with melting points extending down to almost room temperature. Many attempts have been made to

(1) Battelle Memorial Institute, 505 King Ave., Columbus 1, Ohio.
more on page 131



"The Fall of Icarus", by the 18th century illustrator Picart, is an imaginative conception, based on Greek mythology, of space propulsion by muscle power. This interpretation of it by wood engraving is one in a series of similar works undertaken especially for Hercules by Brussel-Smith, noted graphic artist.

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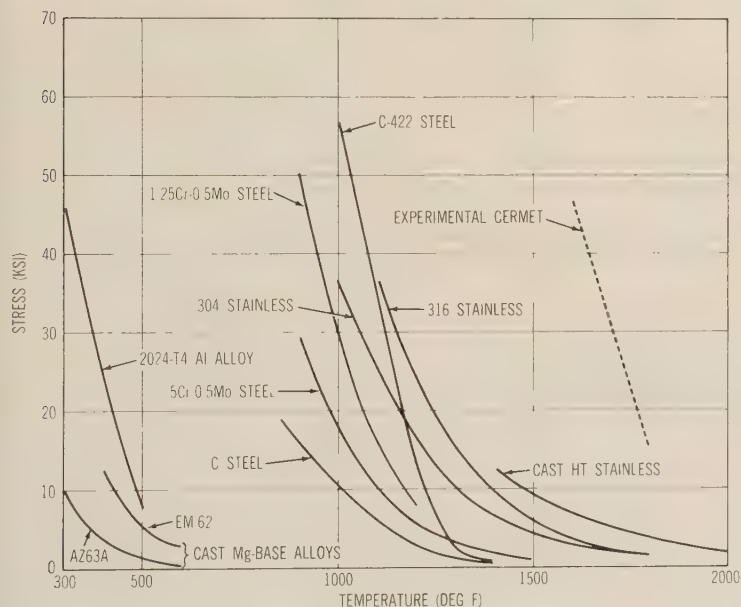
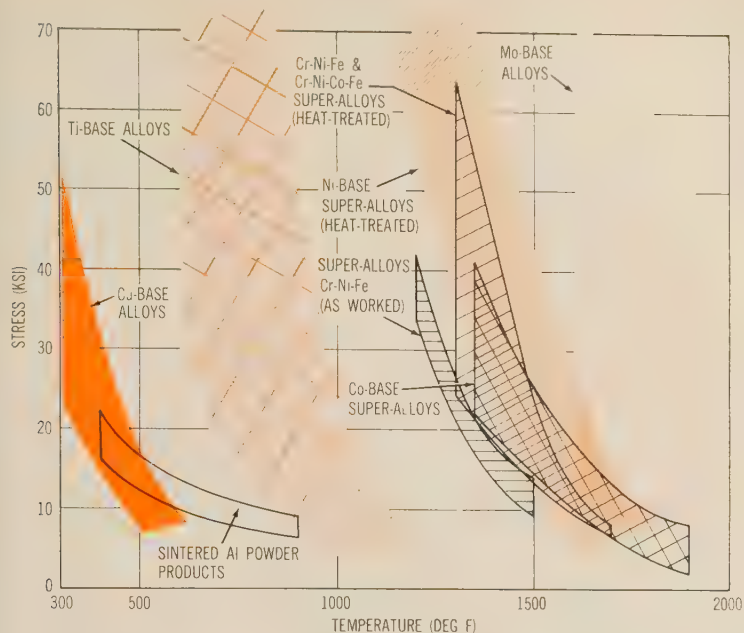


FIGURE 2: Stress vs temperature for 1000-hr rupture for metallic materials. C-422 is a modified 12Cr steel; the curve for cermets must be taken as approximate.)

relate the melting of metals to strength in tension. None has been entirely successful quantitatively, but we do know that at least qualitatively the melting points and tensile strengths of metals are related. Pugh gives an example in which the agreement is particularly good—experimentally determined tensile strengths are very nearly equal for the same homologous temperatures, or percentages of absolute melting temperatures, of several metals (Fig. 1).²

Because of this and other rela-

tions between the physical and mechanical properties of metals, fundamental relationships have become the starting point in the development of new high temperature metals and alloys. The periodic table of the elements, for example, expresses some mechanical properties. Allen and Carrington have shown that there is periodicity in creep strength: chromium, molybdenum, and tungsten, the Group VI metals, show maximum values as the fourth, fifth, and sixth periods

sten, Tantalum, Columbium and Rhenium;" *J. Metals*, 10/5 ('58).

more on page 133

2) J. W. Pugh, "Refractory Metals: Tungsten, Tantalum, Columbium and Rhenium;" *J. Metals*, 10/5 ('58).
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Table I: Rupture-Life Loads (psi)

perature (deg F)	Metal	10 hr	100 hr	1000 hr
1600	W Mo	35,000 28,000	33,000 22,000	31,000 17,000
1800	W Mo	33,000 19,000	28,500 15,000	22,000 12,000
2000	W Mo	29,500 14,500	22,000 11,500	15,500 9,000
2200	W	21,500		

Table II: High Temperature Steels and Super Alloys

	Approx. Maximum Service Temperature (deg F)	Some Typical Commercial Alloys	Comments
at-treatable engineering steels	600	USSS trux, Hy-Tuf, UHS 300, Tricent SAE 4340	super-strength, low-alloy steels
t-work die steels	1200-1400	Vascojet 1000, Potomac M, PHV Nitalloy N	age-hardenable, low alloy steels
rtensitic stainless eels	800	17-4 PH, Stainless W, Type 422, HWDS	martensitic as solution-annealed and aged
ni-austenitic precipitation-hardenable eels	1200	17-7 PH, AM-350, AM-355 PH15-7 Mo, 17-4 Mo	austenitic as solution-annealed, martensitic as aged
stenitic precipitation-hardenable stainless steels	1400	17-10 P, HNM, A286	austenitic as solution-annealed and aged
ld-worked austenitic stainless steels	800	17-5 MNV, 301 extra hard, AISI 201 extra hard, Micromach, Tene-lon	work-hardened austenitic steels
ckel-base alloys	1900	Inconel X, Udimet 500, Waspaloy, René 41	substantial chromium content; age-hardenable primarily with intermetallic compound formation
balt-base alloys	1900	Jetalloy 209, Unitemp L-605 Haynes Alloy 31, HS 21	hardenable by precipitation of carbide or intermetallic formation

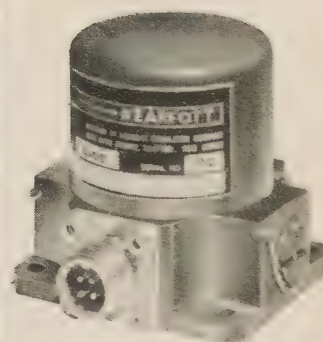
the periodic table are traversed (Fig. 1).³ Columbium and tantalum, which either with vanadium make up Group V metals, are also outstandingly strong. The six metallic elements in Groups V and VI or combinations of them offer the best hope of meeting the very high strength, high temperature de-

mands of metallic structures. Other elements are either too weak at high temperatures or too scarce. Figure 3 shows the maximum strength level of columbium, tantalum, molybdenum, and tungsten. Most of the alloys of these metals lie within the same strength band; future tungsten-base alloys, though, may shift the band somewhat in the direction of higher strength.

A recent research report gives more on next page

N. P. Allen & W. E. Carrington, "Ex-tentory Creep Tests on Metals of High ting Point;" J. Inst. Metals, 82/2 ('54).

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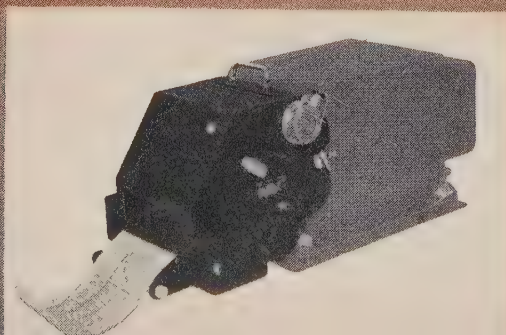
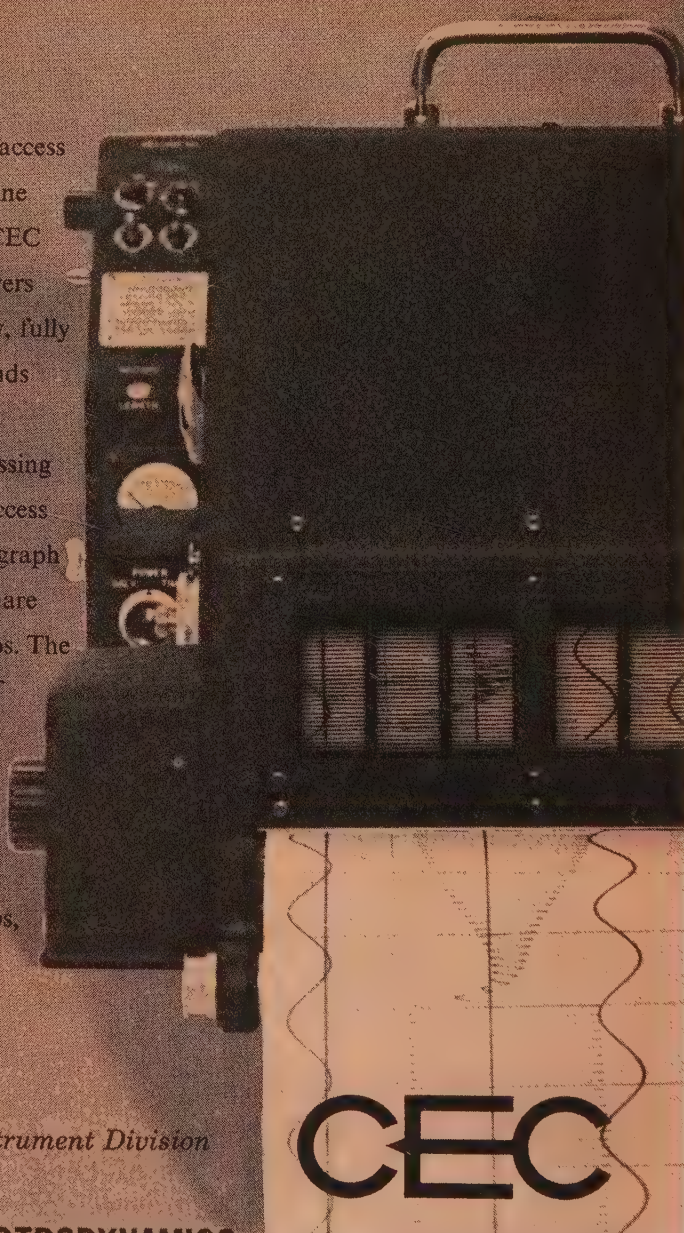
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METALS . . .

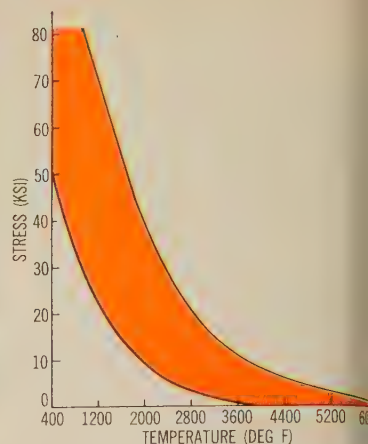


FIGURE 3: Approximate range of ultimate tensile strength vs temperature in short-time tests of columbium, tantalum, molybdenum, and tungsten.

the following short-time limits for 1500 psi tensile strength: molybdenum, 4500 deg F; tantalum, 5000 deg F; tungsten, 6000 deg F. These estimates neglect the effects of creep, atmospheric contamination, thermal shock, loading rate, corrosion, and erosion, and must therefore be taken as maxima.

In high temperature applications, stress-rupture or creep strength usually is more important than ultimate tensile strength, since the latter that any metal or alloy can sustain is inversely proportional to the square root of the length of the period over which the stress is applied. This point is made clear by data on tungsten and molybdenum brought together by Pugh (Table I).⁴

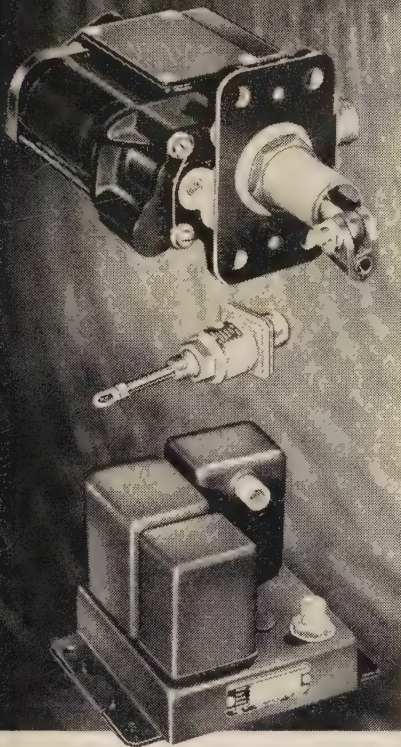
Besides the high temperature strengths, other properties must be considered in choosing among the refractory metals, since they are often of equal or even greater importance. As Table III shows, tungsten and molybdenum are less advantageous than columbium and vanadium when it comes to fabricability. Generally, fabrication difficulties go hand in hand with good high temperature and strength properties.

Extensive development work is being done on alloys of the refractory metals. We have found out, for instance, that small amounts of alloying elements strengthen molybdenum—a 0.5 per cent addition of titanium increases the 100-hour rupture stress at 1800 deg F from 18,000 psi for the pure metal to 45,000 psi. Recently, imports

(4) Pugh, "Tensile and Creep Properties of Tungsten at Elevated Temperatures," *ASME Trans.*, 77, p. 906 (1957).

Write in No. 83 on Reader Service Card

Electromechanical Components and Systems Capability



AIResearch TEMPERATURE CONTROL SYSTEMS

One of a wide variety of temperature control systems developed and produced by AiResearch, this magamp temperature control system is used on the DC-8. It modulates hot jet engine bleed air down from 660°F. to 450°F. for the low pressure pneumatic system serving the air conditioning, refrigeration and ice protection subsystems.

AiResearch diversification and experience provide full capability in the development and production of electromechanical equipment and avionic controls for aircraft, ground handling, ordnance and missile systems of all types.

A.C. and D.C. Motors, Generators and Controls • Inverters • Alternators • Linear and Rotary Actuators • Power Servos • Hoists • Electrical Pyrotechnics • Antenna Positioners • Positioning Controls • Temperature Controls • Sensors • Williamsgrip Connectors • Static Converters.

Your inquiries are invited.



AiResearch Manufacturing Division
Los Angeles 45, California

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January 1960

METALS . . .

**Table III: Relative Standings
of Best Available Refractory
Metals***

	Cb	Mo	Ta	W
Melting temperature	4	3	2	1
Strength above 2000 deg F	4	2	3	1
Density	1	2	3	4
Modulus of elasticity	4	2	3	1
Thermal conductivity	4	2	3	1
Thermal expansion	4	2	3	1
Ductile-brittle transition temperature	2	3	1	4
Recrystallization temperature	4	3	2	1
Room-temperature ductility	2	3	1	4
Cost	4	1	3	2
Formability	1	3	2	4
Weldability	2	3	1	4
State of the art	2	1	3	4

*1 indicates most favorable; 4, least favorable.

improvements in the strength of tungsten have been observed after the addition of a few per cent of ThO_2 . A two per cent dispersion of ThO_2 , for instance, raises the 2500-deg F tensile strength from 22,000 to 42,000 psi. In the case of columbium, alloying additions (e.g., of molybdenum or tungsten) in amounts of about eight per cent double the room-temperature tensile strength.

Actually, the refractory metals and their alloys by and large are used only when absolutely necessary. In many high temperature applications, other metallic materials are preferred—because they are normally cheaper and easier to fabricate and sometimes even offer better strength-weight ratios, oxidation resistance, and other advantages. These other metallic materials can be divided into the super-alloys, which have nickel or cobalt bases, and the ferritic, martensitic, and austenitic steels, which, of course, have ferrous bases.

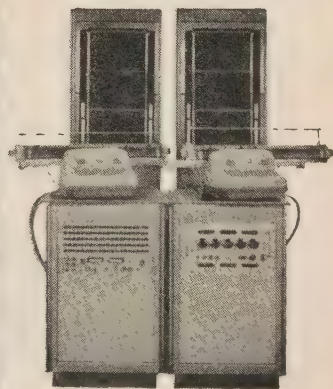
Figure 2 shows a spectrum of available high temperature super-alloys and steels.⁵ The super alloys take up the strength range next to molybdenum and are followed by the austenitic steels. For lower temperatures, lower-alloy steels and titanium-base alloys come into consideration.

Table II represents one of the many attempts to bring some order into the bewildering variety of super-alloys and steels for high temperatures. On a strength-weight basis, the titanium-base alloys are

(5) H. C. Cross & W. F. Simmons, "Alloys and Their Properties for Elevated Temperature Service" ("Utilization of Heat-Resistant Alloys"); ASM, '54.

more on next page

BASIC BUILDING BLOCKS FROM KEARFOTT



DATA LOGGING

Kearfott's broad line of test equipment includes the Scanalog 200-Scan Alarm Logging System which monitors, logs and performs an alarm function of up to 200 separate temperature, pressure, liquid level or flow transmitters. This precise data handling system is equipped with manual controls for scanning rates, automatic or manual logging, data input relating to operator, time, day, run number and type of run. 200 numbered lights correspond to specific points being maintained and provide a visual "off normal" display for operator's warning. System can be expanded to 1024 points capacity and 2000 points per second scanning rate.

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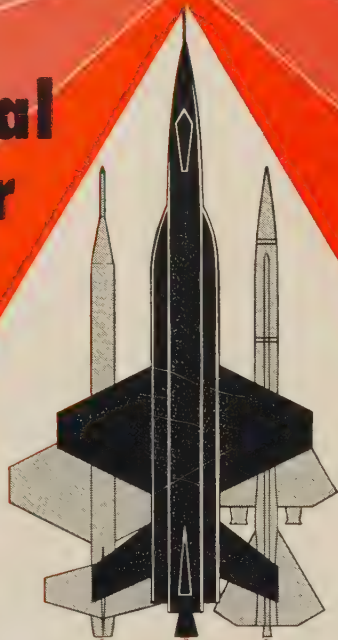
KEARFOTT DIVISION



GENERAL PRECISION INC.
LITTLE FALLS, NEW JERSEY

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Roll Back The Thermal Barrier



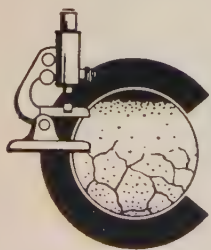
with **CHROMALLIZING**

Oxidation and thermal shock resistance of metals used in jet engines and similar superheat applications are greatly improved with CHROMALLIZING. The patented and proven process of diffusing chromium with other elements into the surface provides an alloy case which is integral with the base metal. It can't peel or flake; the chromium and other elements diffuse uniformly into recesses, pores, cracks and even blind holes.

Alloy	Usual Operating Temperature	Operating Temperature of CHROMALLIZED Alloy
Iron Base (including stainless steels)	1500° F	SA CHROMALLIZED 310 and 321 stainless steels show no failure after 18 hours at 1950° F in an atmosphere containing lead bromide and lead sulfide.
Nickel Base	1800° F	U CHROMALLIZED nickel base alloys are unattacked after 200 hours at 2000° F.
Cobalt Base	1800° F	SAC CHROMALLIZED cobalt base alloys are unattacked after 150 hours at 2200° F.
Molybdenum	Over 2000° F	W-2 CHROMALLIZED molybdenum shows no failure after 400 hours at 2350° F, after 48 minutes at 2800° F, and after one minute at 3400° F.

Ordinary steel can also be chromallized to provide resistance to corrosion, oxidation and wear.

A recent Chromalloy development, IOCHROME (99.997 % pure chromium), is a basis for chromium alloys for use at 2500°F.



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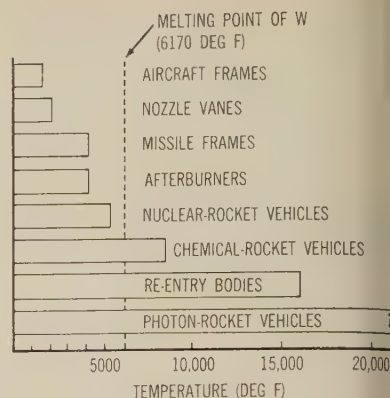
Chromalloy corporation

450 Tarrytown Road • White Plains, New York
White Plains 6-0020

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METALS . . .



TYPICAL temperature extremes of high speed vehicles.

Table IV: Modulus of Elasticity at 1600 deg F for Some Metals and Alloys

	Modulus of Elasticity (10 ⁻⁶ psi)
Mild steel	approx. 8-12
Columbium	approx. 14
HS-21 (aged)	15.4
HS-31	19
Udimet 500	22.4
Rene 41	23
Nicrotung	25.7
Tantalum	approx. 24
Molybdenum	approx. 39
Tungsten	approx. 48

competitive primarily with the precipitation-hardenable semi-austenitic steels.

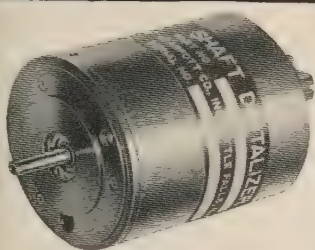
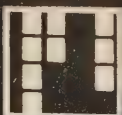
Generally metals and alloys suitable for high temperatures and stresses are relatively difficult to produce and fabricate. Since oxidation or nitride formation or any other contamination must be avoided, melting must be done largely in protective atmospheres or in a vacuum. One interesting recent method involves the remelting under slag of an electrode originally melted under air, which reportedly eliminates inclusions in alloys like A286 and prevents segregation.⁶

The refractory metals must be produced with particular care. Usually either arc melting in a vacuum or an inert atmosphere or an appropriate powder-metallurgy process is used. Tungsten ingots are being produced by electron-beam

(6) "Hopkins Process Upgrades Metals for Critical Use," *Steel*, 145/8 ('59).

more on page 13

BASIC BUILDING BLOCKS FROM KEARFOTT



ANALOG- TO-DIGITAL CONVERTERS

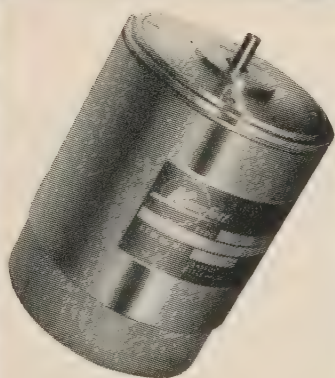
Kearfott's rugged shaft position-to-digital converters are resistant to high shock and vibration and high and low temperature environments. Ideally suited for missile applications, these converters are available for many uses, including latitude, longitude, azimuth or conventional angular shaft displacement conversion and decimal count conversion. Exclusive drum design provides large conversion capacity in smallest size. Combination counter converter assemblies for both visual and electrical readout also available.

TYPICAL CHARACTERISTICS

Kearfott Unit No. P1241-11A
Code Cyclic Binary
Range 0-32,768 (2^{15})
Bits per Revolution 16
Revolutions for Total Range 2,048
Volts D.C. 10.5
Current (ma.) 20
Inertia (gm. cm.²) 20
Unit Diameter (in.) $1\frac{1}{2}$
Unit Length (in.) 3
Life 10^6 Revolutions or 10^3 hours
Static Torque (in.-oz.) .. 2 (break)
1 (running)
Weight (oz.) 5
Maximum Speed (RPM) 600

Write for complete data.

BASIC BUILDING BLOCKS FROM KEARFOTT



20 SECOND SYNCHRO

This synchro, just one of a broad line offered by Kearfott, provides the extreme accuracy required in today's data transmission systems. Kearfott synchro resolvers enable system designers to achieve unusual accuracy without the need for 2-speed servos and elaborate electronics. By proper impedance, matches up to 64 resolver control transformers can also operate from one resolver transmitter.

TYPICAL CHARACTERISTICS

	SIZE 25	Control
Type Resolver	Transmitter	Transformer
Part Number	Z5161-001	Z5151-003
Excit. Volts (Max.)	115	90
Frequency (cps)	400	400
Primary Imped.	400/ 80°	8500/ 80°
Secondary Imped.	260/ 80°	14000/ 80°
Transform. Ratio	.7826	1.278
Max. Error fr. E.Z.	20 seconds	20 seconds
Primary	Rotor	Stator

Write for complete data.

BASIC BUILDING BLOCKS FROM KEARFOTT



INTEGRATING TACHOMETERS

Kearfott integrating tachometers, special types of rate generators, are almost invariably provided integrally coupled to a motor. They feature tachometer generators of high output-to-null ratio and are temperature stabilized or compensated for highest accuracy integration and rate computation. Linearity of these compact, light-weight tachometers ranges as low as .01% and is usually better than $\pm .1\%$.

TYPICAL CHARACTERISTICS

	Size 11 (R860)
Excitation Voltage (400 cps)	115
Volts at 0 rpm (RMS)	.020
Volts at 1000 rpm (RMS)	2.75
Phase shift at 3600 rpm	0°
Linearity at 0-3600 rpm	.07
Operating Temperature Range	-54° + 125°

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miniature

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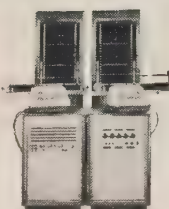
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Electrohydraulic
Servo Valve



Scanalog
200-Scan
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KEARFOTT DIVISION



GENERAL PRECISION INC.

LITTLE FALLS, NEW JERSEY

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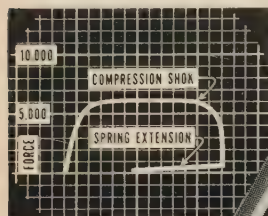
Engineers: Kearfott offers challenging opportunities in advanced component and system development.

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Only SPRING SHOKS

USING LIQUID COMPRESSIBILITY

can produce this Oscillograph . . .



Test Diagram
Courtesy Chance Vought

Draw your
own graph



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NEW HANDBOOK

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METALS . . .

melting in a vacuum. The details of the production methods vary widely—for instance, between the production of chromium, whose oxides are hard to reduce, and that of tungsten, whose oxides are easily reduced by hydrogen.

In the early stages of primary working—for example, in forging—the high strength steels, super-alloys, and refractory metals usually require relatively high deformation forces. Forging of high strength steels and super-alloys often is begun at about 2100-2200 deg F and finished at 1700 deg F. The “stiffness” of some of the more highly alloyed materials becomes quite obvious during working.

The Group V metals columbium and tantalum are cold-forgeable, but their Group VI counterparts must be forged at relatively high temperatures—the forging of tungsten commonly is begun at about 3000-3200 deg F. The relatively high elastic moduli of some of the refractory alloys make them particularly difficult to work (Table IV). Tungsten is especially apt to crack during working.

Except for some of the cobalt-base compositions, most of the high temperature alloys are available in wrought shapes. Their formability varies a good deal. The martensitic steels are not as ductile as the austenitic ones, nor do they work-harden as readily.

With some of the more highly alloyed materials, frequent “in process” anneals may be needed in cold fabrication. Satisfactory welds can be obtained in nearly all instances, except for tungsten and molybdenum, which require special techniques if cracking is to be avoided. Alloys containing appreciable amounts of titanium or aluminum may prove difficult to weld. Certain of the alloys also are markedly susceptible to hot shortness and strain cracking and may require both preheating and slow cooling.

Except for tungsten and some of the cobalt-base types, most of the high temperature alloys are machinable. In heat treatment, the aim with high strength steels and super-alloys is precipitation hardening.—End

JOY. America's Only Electrical Connectors

Fully Rugged—neered for the Really Tough Jobs!



If you're looking for electrical connectors durable enough to take the roughest, toughest demands of today's ground support equipment — you won't find more dependable units than JOY “Space Age” Electrical Connectors.

Proof? Joy Connectors have proved themselves on tough assignments before: into the hot depths of oil wells while carrying delicate recording instruments and holding against pressures to 20,000 p. s. i. . . inside the hulls of submarines and withstanding deep sea pressures even during depth charges . . . carrying 7500 volts of power to giant strip mine shovels . . . feeding full power to nuclear subs with idle reactors while in port.

NO ONE MAKES 'EM LIKE JOY

JOY molded-to-cable connectors are completely watertight and moisture resistant . . . with full durability against distortion, impact, shock, and vibration . . . corrosion-proof . . . in many sizes and styles (with free technical service to discuss your exact needs).

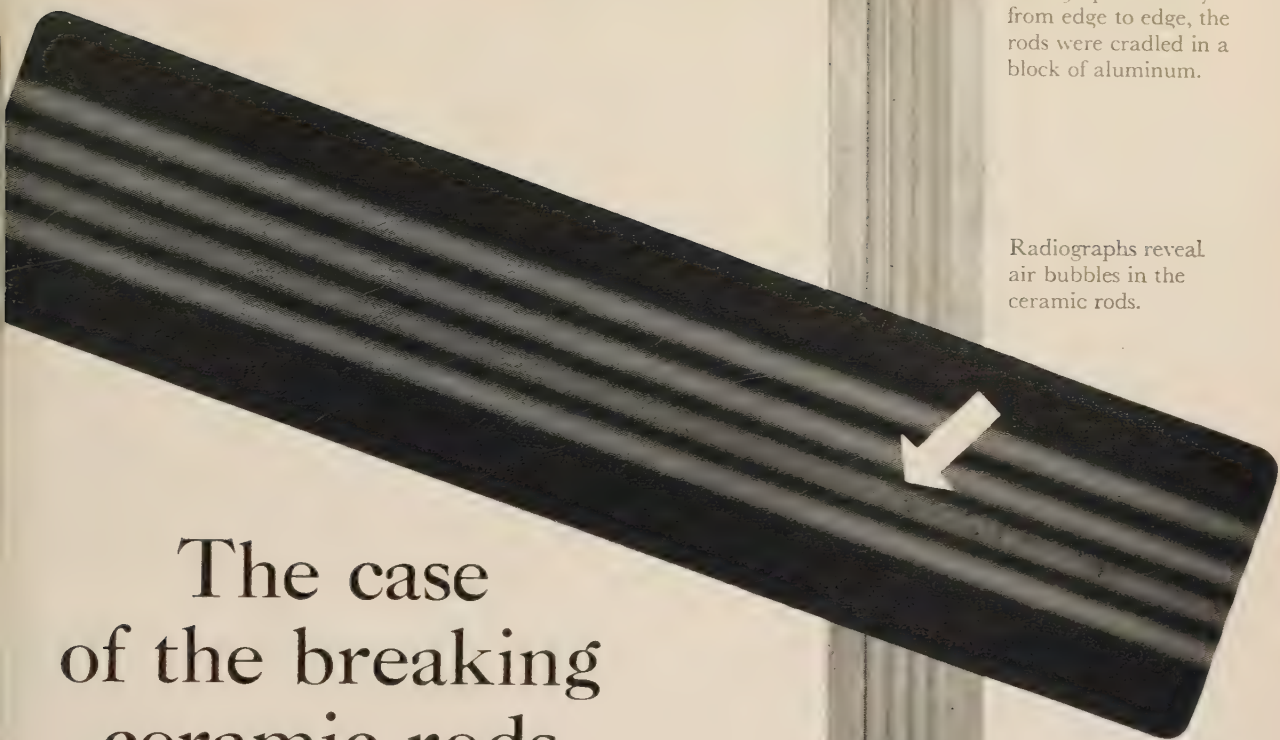
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JOY ELECTRICAL PRODUCTS DIVISION
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SPACE/AERONAUTICS



To obtain even radiographic density from edge to edge, the rods were cradled in a block of aluminum.

Radiographs reveal air bubbles in the ceramic rods.

The case of the breaking ceramic rods

THESE RODS support an electronic element in an intricate traveling-wave tube. They must withstand high temperatures—high vacuum.

Unaccountably, in the early development of traveling-wave tubes, some rods would break. Also some tubes were reluctant to pump down to high vacuum.

To find the reasons, Sperry Gyroscope Company turned to radiography.

The radiographer employed a filter device to obtain uniform density from edge to edge of the radiographic image of the rods. The defective rods were found to contain tiny air bubbles which expanded when the tube was heated and caused the breakage. They also were the cause of the difficulty in degassing the tubes.

In the inspection of assemblies, of castings, of welds, radiography provides a reliable means of examining internal conditions and making sure that only high-quality products are delivered. Often it suggests ways of improving manufacturing methods and cutting costs.

Would you like to learn how radiography can work profitably for you? Talk it over with an x-ray dealer or write for a Kodak technical representative to call.

X-ray Division

KODAK COMPANY, Rochester 4, N. Y.

Read what Kodak Industrial X-ray Film, Type AA, does for you:

- ... Speeds up radiographic examinations.
- ... Gives high radiographic contrast, increased detail and easy readability at all energy ranges.
- ... Provides excellent uniformity.
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NEW PINPOINT NAVIGATION

...FOR AN ARMY ON THE MOVE

Now America's Army has a NEW capability. It can move men and equipment swiftly . . . in and out of restricted areas . . . for dispersion or rapid grouping . . . day or night . . . and with PINPOINT PRECISION.

This new capability—swift mobility with unerring accuracy—was made possible with Ryan's new navigation systems: the Army's first successful self-contained navigation sets, both for fixed and rotary wing aircraft.

This advanced automatic navigator was designed and developed by Ryan Electronics under Army contract and tested by the Army Electronics Proving Ground at Ft. Huachuca. Ryan's AN/APN-129(V) navigator is in pro-

duction for use with the Army AO-1F Mohawk and RL-23D surveillance aircraft, and the Model 120B is guiding H-19 and H-34 Helicopters.

Ryan navigators are light, compact, and trouble-free. With no minimum altitude limitation, they are ideally fitted for the Army's low-level "nap of the earth" operations and vertical envelopment combat missions. Independent of ground facilities, they are practically immune to countermeasures.

The new navigators are outstanding examples of Ryan Electronics knowledge—indicative of Ryan's capabilities in space navigation, doppler inertial guidance, and other advanced electronics fields.

Ryan's rapid growth in electronics is creating new opportunities for engineers

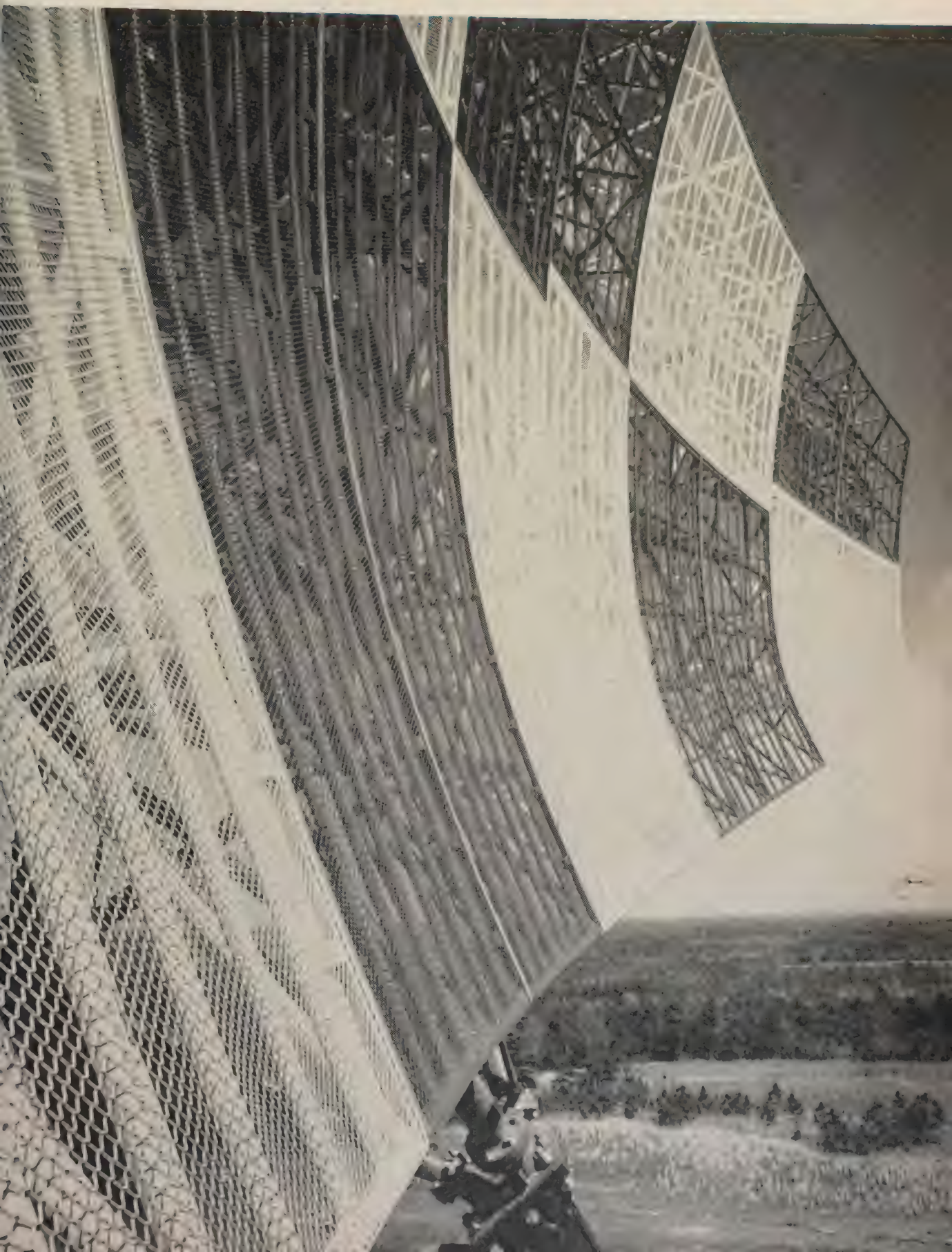
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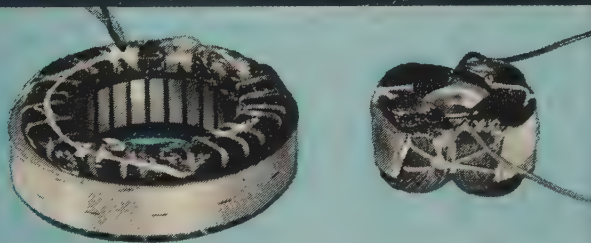
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aerospace *Electronics*



SYNCHROS *for* GYRO PLATFORMS

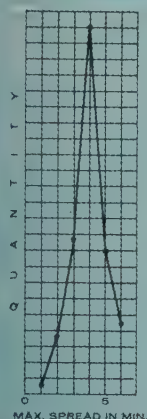
by *cppe*



6' max. error spread Synchro for Gyro Pick-Off

The SG-17- and ST-17- type pancake synchros (SG-18- and ST-18- with housings) are our most standard line for gyro pick-off applications.

These units have been manufactured in large quantity and are readily available for prototype breadboarding. The high accuracies shown on the left are obtainable in standard 26v or 115v units.



Pancake Resolver for Gimbal Mounting

Clifton Precision produces special pancake resolvers for direct gimbal mounting. They were developed for use in cascaded amplifier-less resolver systems and have been trimmed for 10K input impedance, 0° phase shift and a constant transformation ratio, with temperature, at 900cy. Accuracies of 4', perpendicularities of 3' and nulls of 1mv/v of output or less can be held.

Special techniques maintain concentricity between rotor and stator — thus reducing difficulties commonly encountered in gimbal mountings.

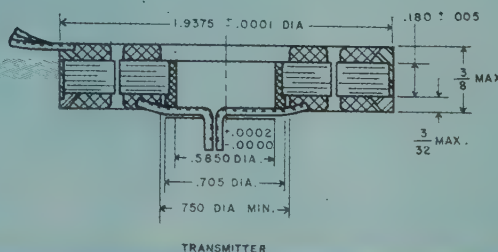
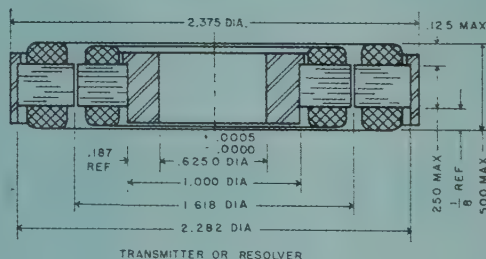
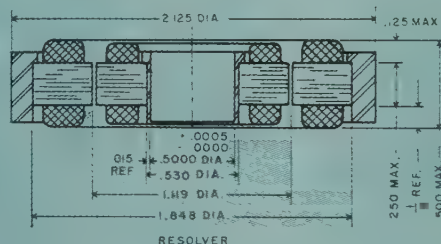


Custom Designed Pancakes

CPPE has developed a number of special pancakes (drawings below) with relatively large bores and narrow stack heights.

Means have been devised to minimize error due to clamping pressures on these thin units.

Special accuracies have been maintained where required. Let us know your needs.



ENGINEERS — join the leader in the rotating components field. Write Desk D. Branch, Clifton Precision Products Co., Inc., Dept. IT.

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aerospace electronics intelligence

ALRI, managed by Burroughs, to extend Sage seaward

AIRBORNE Long Range Input (ALRI) systems management contract was awarded to Burroughs by USAF. Burroughs won out over eight other firms, has 42 months in which to complete its work. Some \$35 million is involved "in the early stages" of the program, it says. Between 50 and 60 per cent of the program reportedly will be subcontracted.

AMC's Aeronautical Systems Center will have executive management responsibility for the program, while ARDC's Early Warning Project Office will handle engineering R&D.

ALRI will extend the range of Sage surveillance seaward. It will link APS-94 radar stations, housed in Lockheed RC-121D recon aircraft, with ground processing and display centers.

TWELVE TUNNEL DIODE types were made available by RCA on an engineering-sample basis. The samples are designed for operation up to 1000 mc, with power consumptions ranging from 0.75 to three milliwatts. Nominal peak (tunnel) currents range from 1.8 to 6.8 ma. Forward voltage ratios are held above peak (tunnel) currents range from 1.8 to 6.8 ma. Forward voltage ratios are held above 4.5. Prices per sample diode run from \$40 to \$100, according to unofficial quotes.

RCA claims its tunnel diode is the smallest mesa device available today. (The PN junction measures 0.001 in. in diameter and 80 angstroms in width.)

RCA HAS DEVELOPED a new type of package for its tunnel diodes. All the samples mount in miniature low-inductance (0.4-muh) ceramic cases. Leads are gold-plated Kovar ribbons smaller than a match head.

ITT claims its ferroelectric converter beats other power supplies

FERROELECTRIC CONVERTER announced ITT Labs is claimed to put out more power per pound than a solar cells or any other existing satellite power supply. A thermodynamic-to-electric-energy converter, the ITT device can be energized by the sun or any other source of sufficient heat—e.g., a nuclear reactor.

The design of the ITT converter is based on

the fact that the permittivity, or dielectric constant, of certain ferroelectric materials varies with temperature. The main element of the unit is a large capacitor using a ceramic ferroelectric, such as barium titanate, as the dielectric.

When the capacitor is heated or cooled, its permittivity drops, causing a rise in the stored electric energy by the factor K_c/K_a , where K_c is the maximum permittivity (which occurs at the Curie point) and K_a the new permittivity. A DC potential connected across the capacitor will thus be amplified. Alternate heating and cooling of the ferroelectric is required for continuous operation.

THE FERROELECTRIC CONVERTER can in a sense be looked upon as a parametric amplifier for dc signals. The frequency of capacity variation is equivalent to the pump, or power frequency.

Practical converters operate at a sufficiently high electrical field strength so that there is no appreciable permittivity drop at temperature changes below the Curie point. They thus operate between the Curie temperature and a higher temperature.

According to ITT, outputs greater than 1000 V already have been obtained directly with a single converter element the size of a dime. By arranging elements in series, outputs of a million volts are theoretically possible, says ITT.

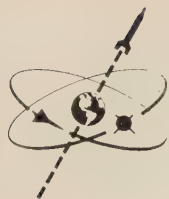
Magnetically coated memory disk is unveiled

REVOLUTIONARY magnetic memory invention was unveiled at the Eastern Joint Regional Computer Conference in Boston, Mass., last month. Called a "Bernoulli disk", it was developed by Laboratory for Electronics in company-sponsored research.

more on next page



COVER STORY—Giant FPS-24 radar designed by GE Heavy Military for USAF uses latest signal-processing circuits as well as super power to extend Sage's range from its Enfaula, Ala., site. Antenna is 120 ft wide, 50 ft high, and weighs 135 tons.



aerospace electronics intelligence

The device consists of a paper-thin disk of magnetically coated mylar. The disk is rotated close to a smooth stabilizing plate in which read-write heads are imbedded. When stationary, the disk is limp and falls away from the plate. But during rotation, air is pumped through the center of the plate and out between plate and disk. The combination of the centrifugal force of the spinning disk and the hydrodynamic force of the air keeps disk and plate separated by a precise distance.

THE NEW MEMORY is small, cheap, and self-adjusting, and can be used in almost any system that conventionally would include a magnetic drum, says LFE. The company also claims its disk is the simplest storage device ever developed to meet the shock and environmental requirements of missiles and satellites.

Electric power from thermionic gas diodes?

THERMIONIC GAS DIODE may prove to be the answer to the problems of electric power generation for missiles and spacecraft—if a joint effort in this area by RCA and Thiokol Chemicals pans out. As described by RCA, the tube consists of a hollow-walled cylinder whose inner wall is the cathode and whose outer wall is the anode. Cesium vapor fills the space between the walls. The cylinder slips over the sleeve of the flame tube of a rocket engine.

Electrical power is generated by conventional thermionic emission, with the heat coming from the rocket exhaust. RCA and Thiokol already have an experimental generator operating. It weighs 3.5 lb and puts out up to 270 W.

ANTI-MISSILE TESTS will be run by ARPA at Roi-Namur Island in the Mid-Pacific. Part of Project Defender, the tests are viewed as one of our first opportunities to collect meaningful data on such questions as whether and at what distance a ballistic missile warhead can be identified by radar, and the time required for positive identification.

Two radars will be used—a modified RCA tracking set originally designed for BMEWS and Raytheon's Pincushion design. The targets will be Army IRBMs launched from Johnston Island, some 1400 miles from Roi-Namur.

THE 80-TON PINCUSHION, being built under a \$15 million RADC contract, will be our

longest range precision radar system. Its name is derived from the more than a dozen needle narrow beams fired from a five-story-high parabolic antenna. The sharp beams are designed to produce high definition displays. High power will be generated by amplatron amplifiers.

"WORLD'S SMALLEST attitude indicating gyro" was developed by Lear for use in manned vehicles as a standby instrument. A conventional aircraft-and-horizon display is used that fits into a standard two-inch-square cockpit panel cutout. The indicator is hermetically sealed and includes two transistorized amplifiers—one for the roll axis, the other for pitch.

INDUSTRY' FIRST solid-state 440-mc beacon transponder was fired into space in a Thor-Able missile that failed to go into orbit. The 0.058-cu in., 6.3-lb box, designed by Texas Instruments' Apparatus Div., enabled radar to track the test vehicle from horizon to horizon during the aborted 14-minute flight, maximum range was estimated at 1300 miles.

TI figures its solid-state beacon will run 40 hours on self-contained batteries. It was specially designed for deep space probes.

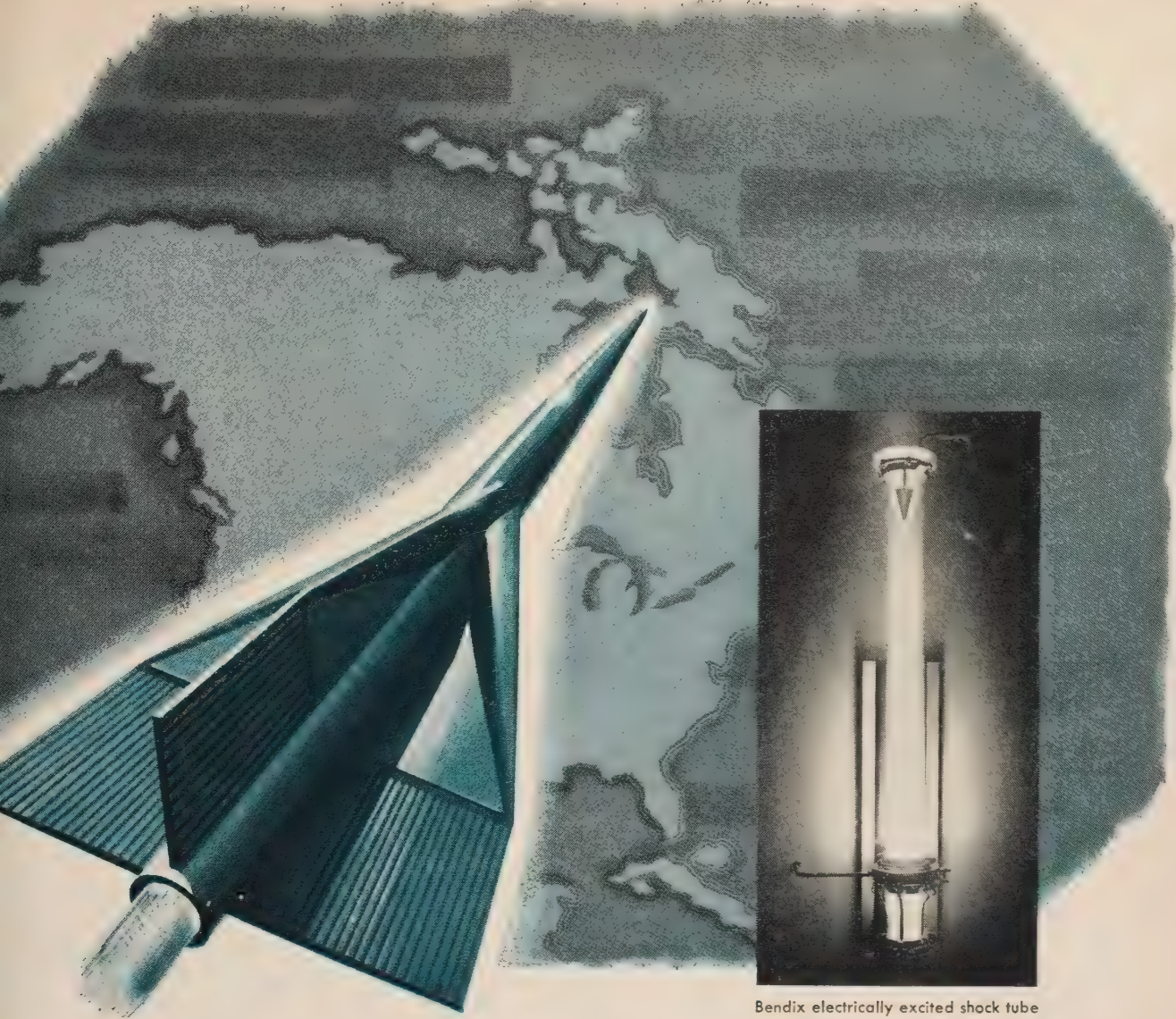
"Active visual decoder indicator" designed to solve ATC problems

LATEST CURE for air traffic control comes from General Instrument. At the recent dedication of its Advanced Development Laboratory at Westbury, N. Y., the company uncovered an "active visual decoder indicator" it has developed under USAF contract. The ground-based device decodes radar beacon signals from an aircraft and displays them as numerals and letters on a counter-type indicator.

The decoder-indicator is triggered by a radar operator who selects the aircraft target that is to be identified by placing an optical viewfinder over its return on the radar scope.

AEROSCORE C missiles scoring system, developed by Aerojet-General, was used at USAF's recent '59 William Tell aerial turkey shoot. The scorer is mounted inside the target or a drone and records and displays vector miss distance, relative course between target and weapon, warhead burst position, and relative velocity. The system is omnidirectional and scores projectiles ranging

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Bendix electrically excited shock tube can be photographed by illumination from hot gases.

PLASMA PRODUCTION

...for magnetohydrodynamic investigations

Hypersonic flight can generate ionized shock layers with electron densities as great as 10^{12} particles per cc. Temperature near the stagnation point can be as high as $20,000^{\circ}\text{C}$. This is the self-generated environment of a missile or aircraft traveling at Mach 20 in the upper atmosphere.

To create these conditions in the laboratory for magnetohydrodynamic and electromagnetic propagation investigations requires a hypersonic wind tunnel. The Bendix electrically excited shock tube is such a research tool. Discharge of a capacitor bank into a conical region at one end of the tube instantly creates a shock wave which is driven down the length of the tunnel past the test body. Flow velocities up to 75,000 fps and temperatures of $20,000^{\circ}\text{C}$ can be generated.

By passing electric and magnetic fields through the plasma in the shock tube, Bendix engineers can measure the attenuation of radio transmission through the ionized layer surrounding hypersonic vehicles. They can also investigate the acceleration of conducting gases for space propulsion, and the feasibility of direct conversion of thermal energy to electrical energy.

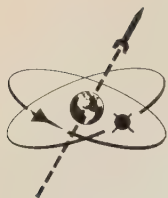
Plasma production is one of the projects being carried out at Bendix Systems Division to solve the technical problems which are the keys to the systems of the future. Other investigations include satellite communications systems, navigation satellites, advanced infrared reconnaissance, and the EAGLE Air-to-Air Missile System. Inquiries are invited from better engineers also looking to the future.

Bendix Systems Division

ANN ARBOR, MICHIGAN



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aerospace electronics intelligence

from large missiles to 50 caliber incendiaries, says Aerojet. Miss distance can be measured out to 5000 ft.

AUTOLANDING SYSTEM contract amounting to \$422,000 was awarded to Autonetics by USAF. Autonetics' system is derived from the recovery device used on the Navaho missile and has been in development for several years.

Essentially the system consists of a special computer and a special radio altimeter. The initial approach is under guidance of a precise localizer and glide slope system like the MRN-7 and -8. At the altitude limit of the glide slope (around 50-100 ft), the aircraft is held in a fixed descent attitude and speed until it reaches the flare point, where the computer generates control signals for the landing roundout.

AUTOMATIC AND MANUAL control modes are provided through an automatic flight control system and an advanced cockpit display using an automatic flight director and horizontal-situation indicator. Sink rates up to 100 fps and air-speeds up to 230 knots will be handled. Approaches can be made at angles between two and 16 deg. The sink rate at touchdown is about two fps.

Research flight tests are scheduled to begin in a USAF TF-102A at Palmdale, Calif. Eventually the system will be evaluated by WADC and FAA.

German approach system being studied by Daystrom

TRACKGUIDE, a flight-director low approach system patented in Germany, is being studied by Daystrom for possible introduction in the U.S. The system works with conventional ILS ground equipment and requires some \$3200 worth of airborne equipment: \$1600 for two airborne receivers and \$1600 for an electromechanical analog computer.

With the computer, the Trackguide measures the deviation from course or glide path and also its first and second derivatives. Ten rudder corrections necessary to put the plane back on the correct flight path are then displayed to the pilot.

FIRST AIRBORNE tactical data system was delivered to the Navy by Litton Industries. Designated AN/ASQ-54, the system will be flight-

tested by Lockheed in a WV2-E Constellation.

The ASQ-54 is to be used in airborne early warning and control in defense of large land masses, attack carrier task groups, and other naval units. Its main components are digital computers and data processors, information displays, and communications networks. In its present version it is built for installation in large land-based aircraft. A smaller version for carrier-based aircraft is also being developed by Litton.

Total of Sperry See sales soon to reach \$2 million

SPERRY'S SEE radar echo enhancer has sold far beyond expectations. So far the company has orders for 200 units, and early this year it expects to reach a sales total of \$2 million.

See is designed for use with surveillance, air-intercept, and tracking radars. It can also be used in civil aircraft to make radar control easier.

TWO IDENTICAL inertial guidance and control systems were installed in a Jupiter IRBM launched recently from Cape Canaveral, Fla. in a unique Army test. One system steered the missile, the other served as a reference to check the accuracy of the first.

Both units were "off the shelf" production Jupiter guidance and control systems made by Ford Instrument. The Army claimed the test was a complete success—both the primary and the reference functioned perfectly, with the missile landing squarely in the impact area.

THIN PICTURE TUBE about the size of an automobile wheel is being developed by RCA for military radar displays. The tube is "reflection-beam kinescope" has a phosphor screen that mounts over a curved inner rear surface instead of on the tube face as in conventional CRTs. The beam approaches the transparent face of the tube, which acts as an "electron mirror" to reflect the beam back to the phosphor. The tube has a 180-deg deflection angle.

Detail will be sharper on the thin tube, claims RCA, because the display appears on the side of the phosphor screen that is struck directly by the beam.

COMPUTER DATA LINK set up by North American Aviation ties together the company's six large IBM computers at its Los Angeles and Rocketdyne Divisions. It uses microwave radio. NAA expects soon to expand the network to in-

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THE NAVY'S POLARIS:

DONNER *helps it think...*

One day soon the U. S. Navy will file a report more fantastic than any sea serpent tale we've ever heard. This will be the launching of the Navy's spectacular Polaris missile from a submerged nuclear submarine. Advanced testing is underway; the Polaris will be ready for the fleet in 1960.

Smaller and lighter than other intermediate range ballistic missiles, this formidable Lockheed developed weapon features much that is new in advanced electronics. It even "thinks" for itself.

One such "think" device aboard the Polaris is a system developed by Donner Scientific Company using as a base a standard Model 4310 Accelerometer. The system monitors flight performance like a policeman directing traffic. If, for example, in the initial portion of the flight, the missile does not achieve sufficient velocity by a pre-determined time, the Donner system aborts the flight. The missile gets the go-ahead only as programmed.

Donner's role in the Polaris project represents another basic contribution from an engineering team which specializes in accurate systems, interlocking time, acceleration, velocity and other inputs designed to meet customers' requirements.

Donner welcomes your inquiries concerning the company's capabilities in this and related fields.

DONNER SCIENTIFIC COMPANY
Dept. 091 Concord, California



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aerospace electronics intelligence

clude computers in its Missile and Autonetics Divisions.

The link, says NAA, will provide a combined computation capability unsurpassed by that of any other computer installation. It also is the first to transmit information from one computer to another without a direct wire link, according to the company. The system was developed for NAA by Pacific Telephone & Telegram and IBM.

ULTRA-RELIABLE microminiature airborne radio receiver is to be developed by Sylvania Electric Products for WADC's Communications and Navigation Lab. The company's \$450,000 contract calls for a UHF receiver capable of 10,000 hours' continuous operation. (The present average time between failures for a typical airborne receiver is about 450 hours.)

Frequency diversity search radars to use the latest signal processing designs

LONG RANGE, high power frequency diversity search radars will be produced by GE's Heavy military Electronics Div. under a \$24 million AMC contract. The company's AN/FPS-24 system (see Electronic Cover) uses many of the latest signal processing circuits and techniques. It is designed to detect supersonic aircraft at longer ranges and higher altitudes than do present operational air defense radars and also to overcome interference from enemy countermeasures, according to GE.

The FPS-24 covers an undisclosed frequency band, within which it can quickly change frequency. It will be used to extend the range of Sage in certain locations.

Sperry Gyroscope's FPS-35, already in production, is designed for a purpose similar to the FPS-24s but operates in a different frequency band.

THE FIRST LAUNCHING of Project Echo communications satellite is planned for spring by NASA. An inflatable 100-ft-diameter sphere will be boosted into a 1000-mile-altitude orbit by a Delta launching vehicle.

If all goes well, the satellite will pass over all countries between 50 deg N and 50 deg S—which includes the entire U.S. except Alaska. The orbital period will be 120 minutes. The maximum period of mutual visibility between the U.S. east and west coasts during a pass will be about 16

minutes. (Echo may be the first satellite that can be seen in orbit by the naked eye).

ACCORDING TO NASA, the satellite will be an inflatable structure of 0.005-in. Mylar plastic with a vapor-deposited aluminum coating. A reflectivity of at least 98 per cent is expected up to 4000 mc.

The main experiment planned in connection with the Echo launchings will take the form of transcontinental satellite bounce communications between Jet Propulsion Lab's Goldstone Tracking Station in California and Bell Telephone Labs' Station at Holmdel, N.J. (see *S/A*, Nov. '59, *Electronics Intelligence*, p. 160). Goldstone will transmit on 2390 mc and Holmdel on 960 mc.

Accelerometers, gyros strapped to frame of vehicle

GIMBAL-LESS INERTIAL aircraft navigation system will be built and flight-tested by Ford Instrument on an experimental basis for WADC's Weapons Guidance Lab. Ford has been working on the platformless inertial system for over a year (under a previous WADC contract). It is also on its own initiative studying the use of such systems in missiles and spacecraft.

This type of inertial guidance differs from more conventional designs mainly in that the accelerometers and gyros are strapped to the frame of the vehicle. The gyros thus have no control over the accelerometers, which are left free to follow all movements of the vehicle. The gyros simply measure the deviations of the vehicle from its original orientation.

FORD will use a "Fordac" high speed incremental computer of its own design in place of mechanical gimbals. Signals from the sensors will be integrated by the computer to provide continuous speed, direction, and location outputs. Besides getting away from the large, high-machine-tolerance gimbals needed in precision inertial systems, the gimbal-less design will provide greater flexibility in the mounting of components.

Many groups have looked into gimbal-less systems. The main argument against such systems has always been that they trade the relatively simple and reliable mechanical gimbals for a complex electronic network. The question whether computer and inertial design know-how has advanced enough so that this trade can be made without too great a sacrifice should be resolved by the Ford-WADC.



*At 00^h 00^m 01^s GMT
January 1, 1960
Martin logged its
390,660,000th mile
of space flight*

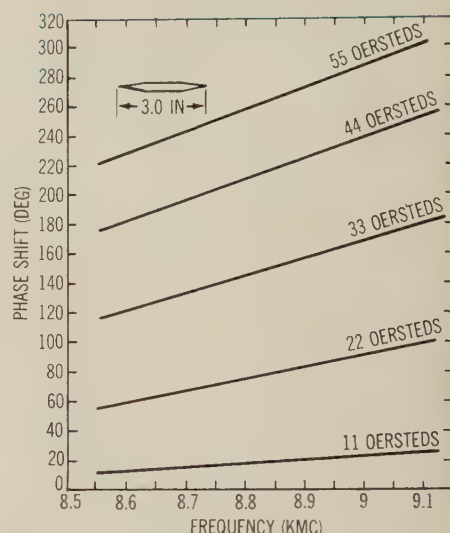
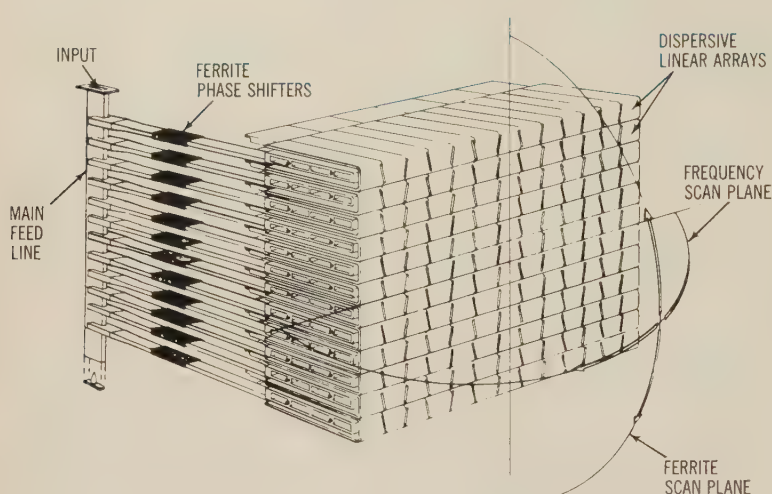


FIGURE 1: Frequency phase shift electronic volumetric scanner (left), in which 12 ferrite phase shifters in the main branch feed line position the beam in elevation.

The phase shifters are folded behind the array in the assembled unit. Right: Phase shift frequency at various magnetizing force levels in an R-1 ferrite.

New ferrite phase shifter paves way for inertialess scanning radar—II

This article, the second in a two-part series reviewing axial ferrite phase shifters, discusses X-band arrays using frequency-phase and phase-phase shift scanning. The design of the phase shifter itself was covered in last month's issue (p. 131).

by **F. E. Goodwin and T. A. Nussmeier**

Experimental Systems Section, Research & Development Laboratories, Hughes Aircraft Co.*

TWO TYPES of inertialess scanning radar antennas have been built and studied by Hughes Aircraft's Microwave Lab. One uses frequency changes to scan the beam in one plane and phase changes to scan it in the other; the second uses phase shift for scanning the beam in both planes.

An experimental 12-by-12-element array has been built that uses the combined frequency-phase shift technique. Twelve ferrite phase shifters in the main branch feed line position the beam in elevation (Fig. 1). As mentioned last month, one of the problems with this

* Research & Development Laboratories, Hughes Aircraft Co., Culver City, Calif.

type of array is the frequency sensitivity of some of the ferrite phase shifters. Evidently the beam deteriorates when it is scanned far off the principal planes because of recycling of the phase shifter programming.

A relatively simple method of compensating such phase errors is based on the fact that the frequency dependence is linear over a five per cent frequency band (Fig. 1). The programming of the phase shifters may therefore be compensated for by a linear control circuit from the frequency programmer. For example, at a frequency f_1 (Fig. 2), a current i_1 is needed for a 360-deg phase change in a typical shifter. While the frequency is going through an excursion to f_3 , the currents in all shifters are reduced accordingly to preserve the correct phase settings.

We will deal here principally with the second type of array, the one phase-scanned in both planes. A phase shifter is used in each of 64 radiating elements and in each of the eight branch lines, so that there is a total of 72 ferrite shifters (Fig. 3). The eight shifters in the feed lines control the beam in elevation; the 64 shifters in the radiating elements control the beam in azimuth.

It is essential that each vertical column of phase shift units have the same phase vs current characteristics. Therefore all units must be at a uniform temperature and magnetically shielded from each other. The insertion loss of all the shifters must also be uniform, so that no errors will occur in the amplitude distribution of the elements.

The main feed line and the eight branch feeds have identical slot configurations. Shunt slots are used on the narrow wall of standard RG-52 X-band waveguide to provide the eight-element resonant feed line. The energy is series-fed into another RG-52 waveguide (Fig. 4). The aperture is a 28-db Dolph-Tschebyscheff taper.

The radiating element in the phase-scanned array is an inductive iris matched to free space at 8820 mc.

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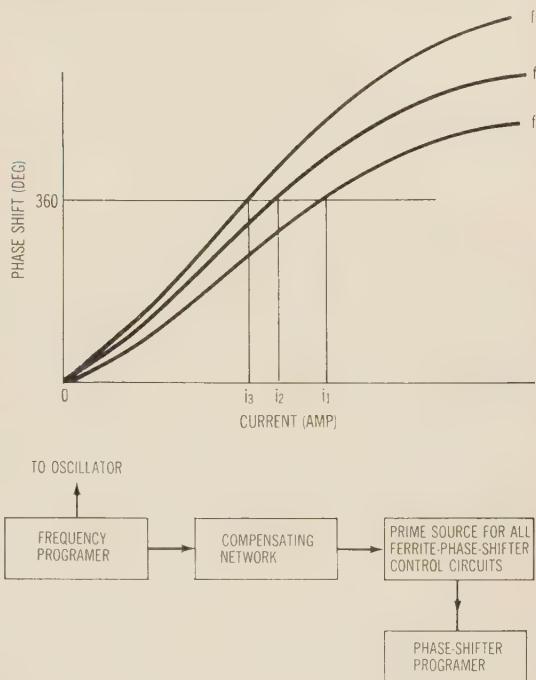


FIGURE 2: Phase shift error corrector for frequency-phase scanning.

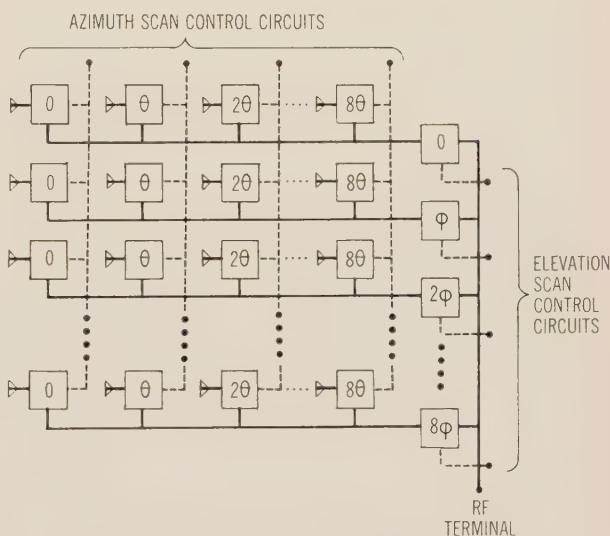


FIGURE 3: Schematic and completely assembled array of ferrite volumetric scanner. The beam is scanned in elevation and azimuth by separate control circuits that change the phase of the RF input to the antenna by means of the ferrite elements.

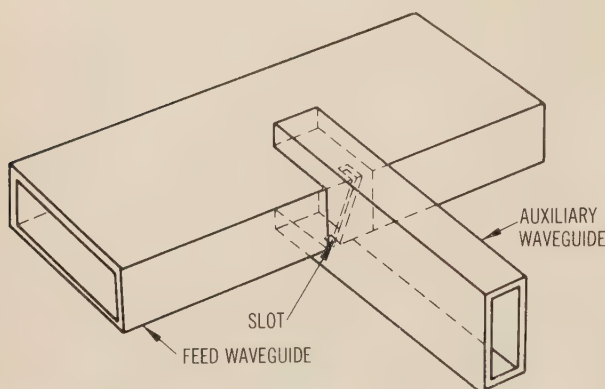
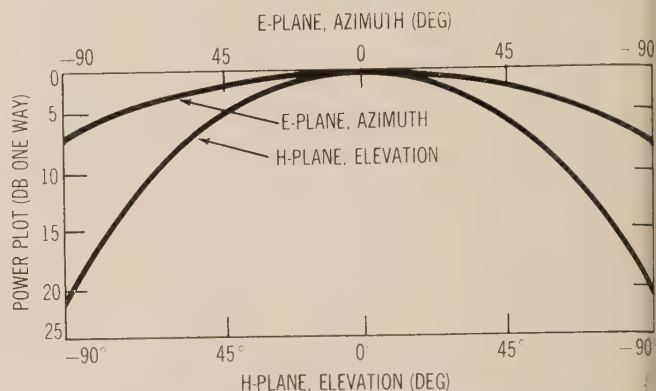


FIGURE 4: Shunt series slot coupling (left) through narrow wall of RG-52 X-band waveguide provides eight-element resonant feed line. Energy is series-fed into another RG-52 waveguide. Center: Approximate radiation



pattern of inductive iris matched to free space at 8820 mc and used in phase-scanned array. Right: Rectangular mapping of beam position as a function of beam angle for independent phase-phase scanning.

Figure 4 shows its approximate radiation pattern. The measured VSWR of the final assembly array is 1.1 at the broadside beam position.

Calibration of the phase shifters had to be done under conditions quite close to those of actual operation. This meant that temperature control and magnetic shielding problems had to be solved before calibration. Fortunately, the antenna configuration allowed relatively simple solutions of both problems. The 64 shifters in the main body are divided into eight vertical columns of eight units each. The field coils in each column are connected in series, and all eight columns have a common bus bar at the bottom of the array. Thin sheets of steel are used as shielding between the columns.

Shielding between units in the same column is not as critical, since these units may be calibrated even while they are interacting. In any case, we found that small strips of steel between the shifters eliminates most of the interaction. Measurements of the shielded array

showed less than four degrees of interaction in the columns and less than two degrees in the rows.

For temperature control, heaters are used. A thin sheet of phenolic is glued to each of the nine steel shields separating the columns. Three separate heating circuits are pancaked on the phenolic with Dow Corning A-4000 adhesive.

Each heater is controlled by a separate thermostat and powered from a 28-V ac or dc source. Twenty-four heaters and thermostats regulate the temperature of the phase shifters on the main branch feed line.

The temperature distribution of the array under typical operating conditions is less than ± 1 deg C in the main body and ± 3 deg C in the main branch feed. These values correspond to phase shift errors of four and 12 deg, respectively. Because of the poorer regulation of the branch array, sidelobe levels of the antenna patterns are higher in the elevation plane than in the azimuth plane.

Temperature balance poses problem

Figure 3 shows the completely assembled all-ferrite scanning array in the state of development at which the experimental data were taken that are given here. As previously mentioned, the most serious shortcoming of this arrangement of phase shifters in the main branch feed line lies in the difficulty of maintaining equal temperatures in the elevation phase shifter branch.

Programing of the currents in the phase shifters is simplified by the independent control available in the two scanning planes. Since we knew that the azimuth plane (E-plane) is one of strong mutual coupling of radiating elements, we chose the maximum scanning angle in this plane as ± 21 deg from the broadside beam position. The elevation scan angle was chosen as ± 28 deg. (Larger scan angles are possible for arrays with closer element spacing.)

Azimuth beam positions (μ) and elevation beam posi-

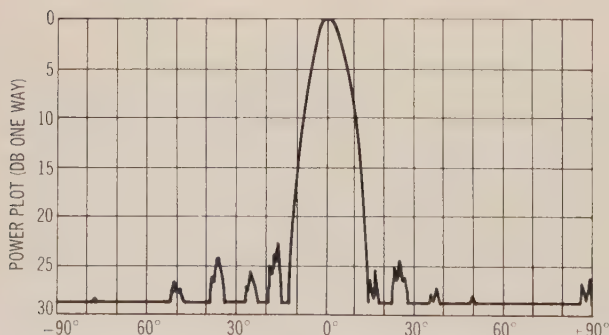
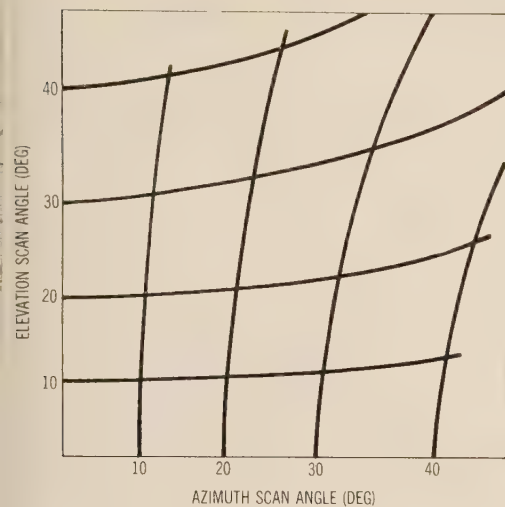


FIGURE 5: Azimuth radiation pattern of an array before the addition of phase shifters.



Elevation Phase Shifter	Elevation Angle (deg)			
	4	12	20	28
1	19°	56°	91°	126°
2	37°	112°	183°	252°
3	56°	168°	274°	18°
4	74°	224°	6°	144°
5	93°	280°	98°	270°
6	111°	336°	190°	36°
7	130°	32°	281°	162°
8	149°	88°	12°	290°

Azimuth Phase Shifter (Column)	Azimuth Angle (deg)			
	3	9	15	21
1	14°	42°	69°	96°
2	28°	84°	138°	182°
3	42°	126°	207°	288°
4	56°	168°	276°	24°
5	70°	210°	345°	120°
6	84°	252°	54°	216°
7	98°	294°	123°	312°
8	112°	336°	192°	48°

tions (v) we calculated from the geometric relation between the uniform progressive phase shift between elements—in the horizontal plane (θ) and the elevation plane (ϕ)—in the element spacing (d):

$$\sin \mu = \theta/kd, \sin v = \phi/kd,$$

where k equals $2\pi/\lambda$.

The Table shows the relative values of phase for each phase shifter in the elevation scan branch and for each column of phase shifters in the azimuth scan group. Figure 4 shows the rectangular mapping of beam positions as a function of beam angle for this arrangement.

Driving current is provided by two telephone stepping switches—one controls the azimuth position of the beam; the other, the elevation position. Since each phase shifter has a total of only eight programmed current values, the eight positions can be scanned very quickly.

Figure 6 shows the basic current control circuit and the completely programmed apparatus. After an eight-step sequence, the azimuth switch triggers the elevation switch one step and then repeats its performance. In this way, the beam is positioned from left to right and from top to bottom for a raster scan.

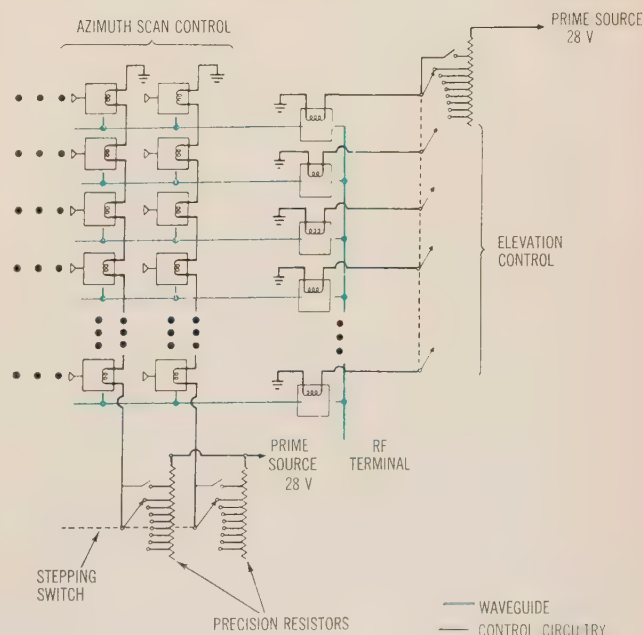
Before the array was assembled, the radiation pattern was plotted without any phase shifters (Fig. 5). Although the designed sidelobe level is -28 db, the dimensional errors in the linear arrays alone are enough to produce an actual -24 db. Once we knew the capabilities of the array itself, we were able to determine more closely the effects of errors in the ferrite shifter.

After antenna and programmer had been assembled, we took a complete set of azimuth patterns (Fig. 9). Second-order beams were present, but these we had expected on the basis of the element spacing and the element pattern in the E-plane. These second-order effects can be eliminated by reducing the element spacing.

When you compare the azimuth patterns of Figure 9 with those of the antenna without phase shifters (Fig.

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FIGURE 6: Control circuit for a ferrite scanning array.



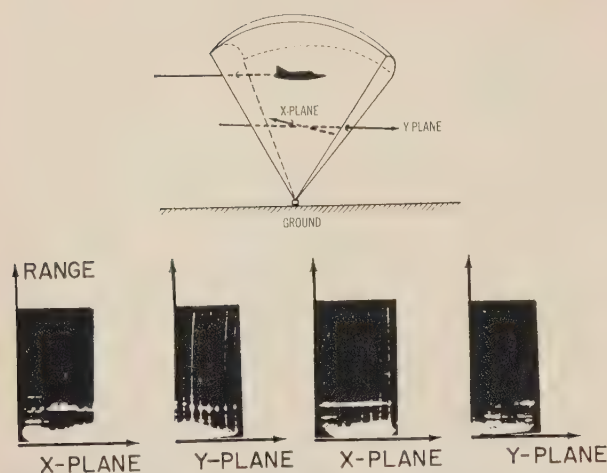


FIGURE 7: B-scan presentations. Left: Azimuth (X) and elevation (Y) plane presentations with an aircraft passing through the Y-plane at constant X. Right: Presentations with an aircraft passing through the X-plane at constant Y.

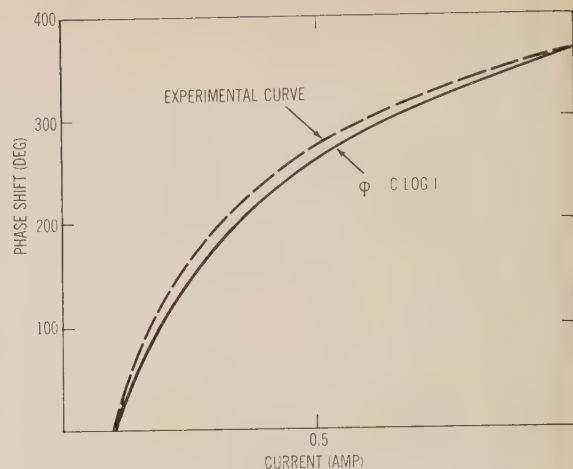


FIGURE 8: Experimental and logarithmic phase-shift-vs-current curves show why the calibration of phase shifters relative to each other does not suffer greatly from variations in primary voltage.

5), you can see that no important beam features are destroyed by phase errors in the shifters. It is worth noting, though, that the azimuth patterns of *Figure 9* were produced by the phase shifters in the main body of the array, where the temperature is closely regulated.

We ran a series of marginal tests to find out which factors affect the beam and which don't. One significant result showed that changes in primary voltages do not cause serious beam pattern variations. Although the phase shifter currents are calibrated for 28 V, the patterns didn't suffer seriously when the voltage was varied between 31 and 26 V.

We can conclude, therefore, that the phase-shift-vs-current is sufficiently non-linear to compensate for the reduction on the programming currents. For exact compensation, the relation:

$$\Delta\phi(\Delta i/i) = \text{constant} = i d\phi/di$$

must hold. Therefore:

$$\phi = C \log i.$$

Figure 8 compares the logarithmic curve with an actual phase-shift curve. The close similarity of the two curves explains why the calibration of the phase shifters relative to each other is not greatly impaired when the primary voltage is varied. It follows that poor prime voltage regulation does not significantly affect calibration.

In another marginal test, we used an open circuit in one of the programming circuits. The pattern immediately deteriorated. With very large arrays, however, the pattern would not be degraded by only a single similar programming error.

Figure 9 also shows the elevation patterns. The effects of temperature gradients in the array can be seen if you compare the radiation patterns in this plane with those in the azimuth plane. The general variation in temperature among the elevation phase shifter is ± 4 deg C. This variation gives rise to phase errors of nearly 30 deg. Because of the element pattern, there are no second-order beams in this plane (H-plane).

The ferrite phase-phase scanner has been installed in a radar with a peak input power of 10 kw and used to observe both ground and air targets with B-type displays

showing both azimuth and elevation vs range. In experiments with a Cessna 140 as the aerial target, we tested the three-dimensional tracking capabilities of the system. In these experiments, the broadside vector of the antenna was nearly vertical. An aircraft entering the sector in level flight has its position recorded on both azimuth-range and elevation-range displays. (*Fig. 7*).

Feasible for many operational systems

The work done to date at Hughes Aircraft definitely shows that ferrite phase shifters are feasible for many operational systems.

Large phase-scanned systems are feasible only if independent azimuth and elevation control is possible. In any array containing n^2 radiating elements and n^2 or more phase shifters, separate control circuitry and programming for each phase shifter are not practical; however, for independent azimuth and elevation control, only $2n$ control circuits are needed, and this is not an impossible number.

The array we have discussed has this type of control—one phase shifter is needed in each of the main branches and one in each radiating element, making a total of $n(n+1)$ phase shifters. The maximum power handling capability of this arrangement is limited by the number of main branch phase shifters. With the best present ferrite for X-band phase shifters (General Ceramics' R-1), the eight-by-eight array can handle about 10 kw peak power.

If this scanner is scaled up in size to produce a one-degree beam, it could radiate 100 kw peak and 250 W average power. The power handling capability is inversely proportional to the beamwidth. Obviously this power limitation is too narrow for some larger beamwidth systems.

The power handling capability is much greater if the phase shifters in the main-branch feedline are eliminated. The power would then be divided among n^2 shifters. We could independently control azimuth and elevation scanning with $2n$ circuits by using two phase

shifters in cascade in each radiating element. Half (n) of the circuits would control the front phase shifters for scanning in one plane and half would control the rear phase shifters for scanning in the other plane. This arrangement ought to be adequate for any foreseeable power requirement.

This scheme would also be possible if we used only one phase shifter but with two control windings in each radiating element. Each winding would control the phase through a 360-deg cycle. However, the non-linearity of the phase shift vs current characteristics for axial phase shifters makes this double-winding scheme impractical (at least for the present).

With the X-band shifter using a R-1 ferrite, the array would radiate five megawatts peak power and 12.5 kw average at one degree beamwidth. With a three-degree beam, peak power would be 500 kw and average power 1.25 kw. Furthermore, in these very large arrays more efficient ferrites with low insertion losses can be used. Ferrites with a narrow ferromagnetic resonance line width are limited in their ability to handle high peak powers, but this disadvantage is offset because a large array has many ferrites.

For example, one such ferrite, General Ceramics' R-4, has an insertion loss of 0.25-0.4 db when used in a phase shifter. An array using $2n^2$ of these devices in the manner we have described can handle upward of 2.5 Mw peak and 100 kw average with a one-degree beam and 300 kw peak and 10 kw average with a three degree beam. An array for a one-degree beam will have 20,000 phase shifters and 200 control circuits. Control power for the entire driving circuitry will be less than 10 kw. An array for a three-degree beam will require only about 2000 shifters and 66 control circuits. Its control power would be less than three kilowatts.

Two methods of frequency-phase scan

For frequency-phase shift scanning, two methods are of interest. The first uses phase-shift scanning in the main branch feed and frequency scanning in the array. However, the shifters in the main-branch feedline sharply limit the power handling capability.

The second method allows much higher powers. It uses frequency scan in the main feed and individual

ferrite phase shifters in each of the radiating elements. In this scheme, n^2 phase shifters and n control circuits are needed (in addition to the frequency control).

Actually, the feasibility of any kind of frequency-ferrite array has been established by the development of a phase shifter that operates over a ± 3 per cent frequency band. It should be possible to extend this range.

In considering the combination of frequency and ferrite scan, system planners may elect to use phase shifters in the main branch feed. These simplify the ferrite part of the scanner but complicate the array problem—closely stacked dispersive arrays constitute a formidable design problem.

In our work on electronic volumetric scanning, our first choice was to use phase shifters in the main-branch feedlines and frequency-scan the arrays. We soon ran into engineering difficulties, and it was decided it would be better to design and build an all-ferrite scanner. An eight-by-eight all-ferrite scanner was demonstrated at Hughes Aircraft in August 1958. The frequency-ferrite system using dispersive arrays was completed last May.

On the basis of our experience, we have concluded that, when frequency-ferrite scanning at X-band and high power handling are required, the main feedline should be dispersive for scanning the beam in one plane and ferrite phase shifters should be used at each radiating element in the other plane. For those future systems in which high power and operation at a constant frequency are required, the all-ferrite configuration, with two ferrite phase shifters in cascade feeding each radiating element, looks most promising.

The specific values of the power handling ability of the arrays we have described apply only to arrays using General Ceramics R-1 and R-4 ferrite materials at X-band. Since the power limitations of ferrites are less serious at frequencies below X-band, ferrite scanning can be used in extremely high powered radars.

An S-band model of the axial-feed device is under development in the Microwave Lab at Hughes Aircraft. Although a different ferrite material is used, the characteristics of the phase shifter closely parallel those of the X-band device. The conclusions we reached in working with X-band systems, however, do not necessarily apply to this model.—End

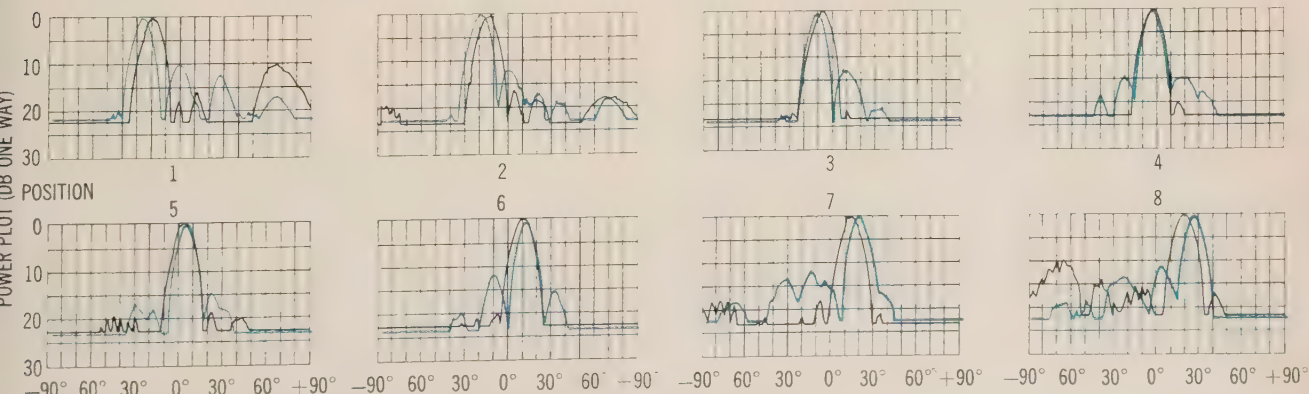


FIGURE 9: Radiation patterns of a ferrite-loaded array in the azimuth plane (black) and the elevation plane (color) for beam positions 1 through 8.

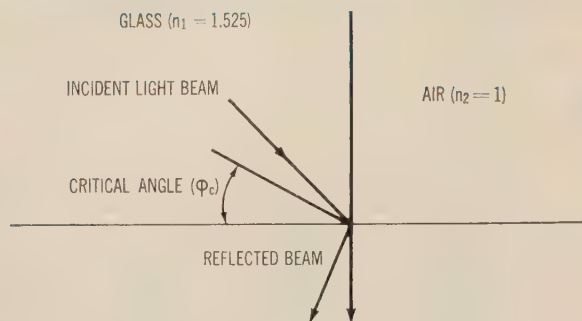
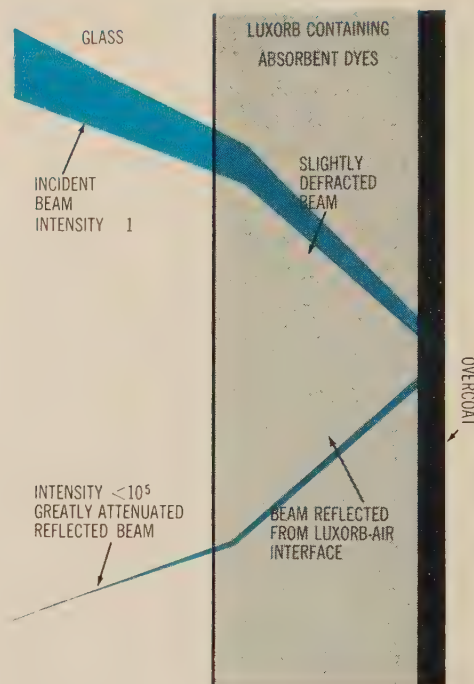


FIGURE 1: Geometry of reflection of incident light at a glass-air interface (left). According to optical theory, radiation in a medium that arrives at the boundary of another, less dense medium at an angle greater than critical will be totally reflected back into the denser medium. The critical angle is found from $\phi_c = n_2/n_1 = 1/1.525 = 40 \text{ deg } 58 \text{ min}$. Right: Attenuation of incident light by coating a glass-air interface with a film the index of which very nearly matches the refractive index of the glass. The overcoat reinforces the attenuation of the beam.



"Transparent black"

absorbs light noise in astro-trackers

A key element in astro-inertial systems capable of day and night star-tracking, "this transparent black" film has many applications throughout the optical field. Applied to certain surfaces of a lens or prism, this film will cut unwanted light by a factor of 1/100,000.

by John Monroe and T. E. Rodgers,

Development Engineers, Nortronic Div.,
Northrop Corp.¹

EVERY ASTRO-INERTIAL design must include provision for restricting the field of view of the photo-sensitive detector to the image of a distant star. This can be done by an optical system that exploits the fact that the unwanted light is mostly "off-axis" with respect to the line of sight between telescope and target. Prisms or light traps can be used to discriminate between on- and off-axis light and to divert the unwanted radiations away from the optical sensor.

A problem remains, however. How do you dispose of the diverted, unwanted radiations? Unless they are substantially attenuated as well as diverted, they can,

(1) Nortronics Div., Northrop Corp., Hawthorne, Calif. Since the writing of this article, Mr. Monroe has become head of scientific research at Firestone Tire & Rubber's Guided Missile Div. and Mr. Rodgers has retired.

through multiple internal reflection, eventually reach the photocell and appear as noise.

As part of its astro-inertial development program, Nortronics has worked out a concept of off-axis light attenuation that proved reliable under actual operating conditions. This concept is based on the principle of matching refractive indices. The matching element at the glass prism-air interface is a coating of absorbent organic dyes. The index of this coating on the surface of the prism on which the off-axis light impinges from within is matched very closely to the refractive index of the glass itself. The so-called critical angle (measured from the perpendicular) then becomes very large and substantially all the light is compelled to enter the coating, where it is absorbed by the dyes.

For a perfect match, ϕ_c is 90 deg

For a perfect match, the critical angle (ϕ_c) is 90 deg, where:

$$\phi_c = \sin^{-1}(n_2/n_1),$$

n_2 and n_1 being the indices of refraction for adjoining mediums. Figure 1 shows how a beam of light, under the conditions of the total-reflection law, would normally be internally reflected from a glass-air interface. No coating is used on the glass. Figure 1 also shows a glass coated with a film whose refractive index closely matches that of the glass. An "overcoat" containing carbon black is added to keep the coating thin for large attenuation.² As we can see, an incident beam of light after a double passage through the colored film is attenuated by a factor of more than 10,000.

The Luxorb³ coating compositions developed at Nortronics are binary, film-forming mixtures of clear resins whose refractive indices are controllable over a desired range by fixing the proportions of the constituents. Arochlor Resin 5460, a chlorinated polyphenyl made by Monsanto Chemical, is used as the high-index constituent. In it, a black mixture of oil-soluble dyes is dissolved to give the film the right refractive index together with other necessary properties like optical clarity, adhesion, and freedom from halation (light-scattering).

The "transparent black" composition is painted on the edges of lenses and other optical components where light reflections must be eliminated that would cause false images or glare in the focal plane. Luxorb is particularly important in eliminating glare in stellar guidance systems tracking in view of the sun or moon.

Luxorb operates on rays of light in a specular manner and does not rely on attenuation by scattering. Each ray is directed to attain maximum absorption. Desired rays are channeled through the optical system so that they avoid all Luxorb-coated surfaces.

Now the question of allowable tolerance in matching the refractive indices of coating and substrate (glass) naturally arises. The amount of light internally reflected

(2) Because a true solution of dyes in a polymer matrix may be considered to obey Beer's law, the nearly complete attenuation of light even in a double passage through the film would require a film of very great thickness. Beer's law states:

$I = I_0 e^{-kx}$, where I is the intensity at distance x into the film; I_0 , and the incident intensity; e , the base of natural logs; and k , the absorption coefficient.

(3) Registered trademark.

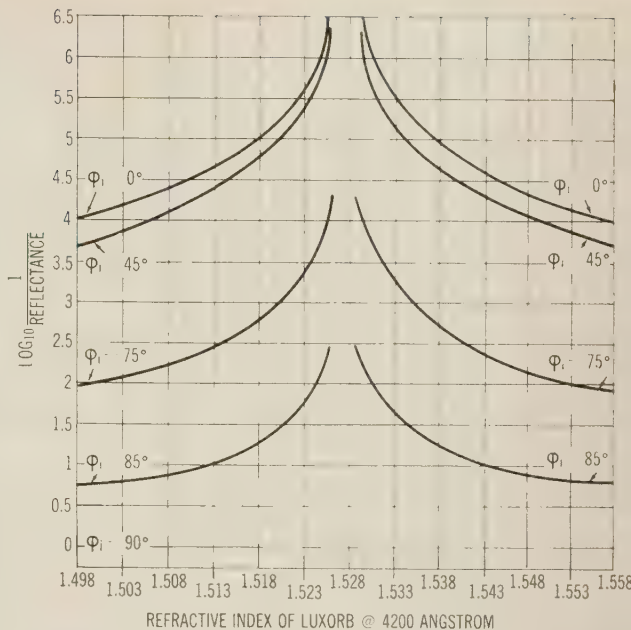


FIGURE 2: Mismatch of Luxorb systems as a plot of optical or reflectance, density vs the refractive index of Luxorb, where ϕ_1 is the angle of incidence in the glass substrate and the refractive index of the glass is 1.525.

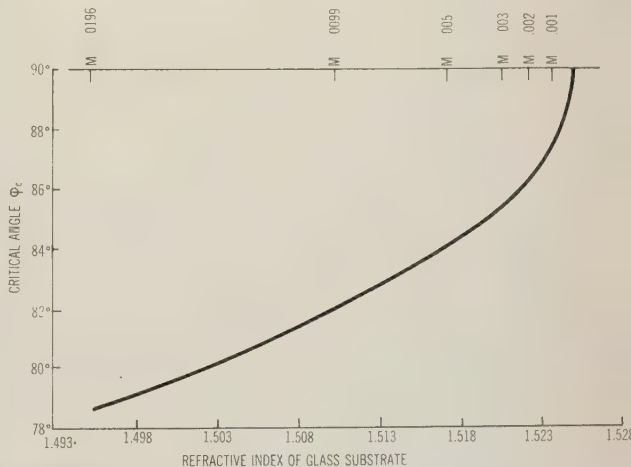


FIGURE 3: Critical-angle variation with Luxorb mismatch, where the refractive index of Luxorb is 1.525.

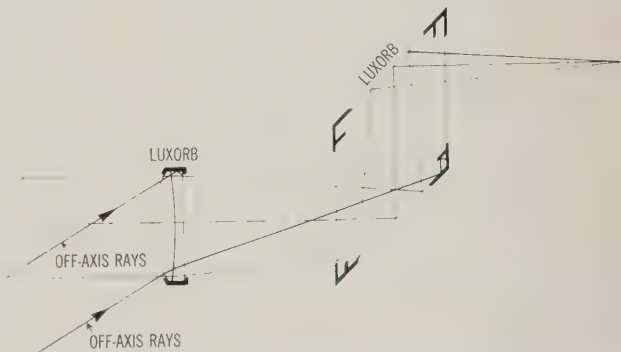


FIGURE 4: Luxorb in a telescope system. The edges of the lens at right are coated with Luxorb and so are the corners of the rhomboid prism. The prism has slots near the corners. Coated with Luxorb, these slots provide multiple reflection and annihilation of off-axis light.

more on next page

from a coated surface can be calculated from Snell's law:

$$\sin \phi_i / \sin \phi_r = N_r / N_i,$$

and the combined form of Fresnel's formulas:

$$R = \frac{1}{2} \left\{ \frac{[\sin^2 (\phi_i - \phi_r)] / [\sin^2 (\phi_i + \phi_r)]}{+ [\tan^2 (\phi_i - \phi_r)] / [\tan^2 (\phi_i + \phi_r)]} \right\},$$

where R is the proportion of light reflected at the angle of incidence; ϕ_i and ϕ_r are the angles of incidence, and refraction, respectively (both determined by the ratios of the refractive indices of coating and glass); N_r is the refractive index of the coating; and N_i , the refractive index of the glass.

Figure 2 plots optical density ($\log_{10} 1/R$) as determined by the refractive index of Luxorb and the ϕ_i . Figure 3 shows the effect of different degrees of mismatch between coating and glass on the critical angle (ϕ_c), which equals $\arcsin N_r/N_i$. The mismatch (M), a simple function, is defined by:

$$M = (N_r - N_i) / N_i.$$

Figure 3 shows that a value of 0.001 insures a critical angle greater than 88 deg. If the refractive index of the coating is somewhat greater than that of the glass, there can be no critical angle.

Effect of dispersion on coating

What effect does dispersion have on the efficiency of the coating? If equal cutoff of all ranges of the visible spectrum were required, dispersion effects would be a major factor. Luckily, the optical sensors used in astro-inertial systems have responses varying with wavelength, and if coating and glass are matched in the region of peak spectral response, the effect of dispersion is not serious.

Quite naturally, the optical coatings are evaluated according to the attenuation they present to the incident light. This attenuation is measured in a test setup in which a light beam is reflected from the coated broad surface of a 45-deg prism (Fig. 5).

The working faces of the prism must be optically polished; the ends may be left rough-ground. It has been found that Luxorb works relatively poorly on a ground face—the surface irregularities present many small areas in which the critical angle is reached, and scattering inevitably results from the lack of a perfect index match between coating and substrate. Part of the broad, or hypotenuse, face is left uncoated. The mea-

surement of the reflection from this face gives the reference value against which the attenuation of the Luxorb-coated portion is measured.

After reflection from the prism, the image of the light source (generally a coiled filament) is focused on the sensor (a Welch Densichron in Nortronics' setup) and not on the reflecting face of the prism. The average attenuation of light reflected by Luxorb, as determined by this method, amounts to 10^{-4} . In some cases, attenuations greater than 10^{-5} have been measured.

Final adjustment by trial and error

A special multiple prism was made of segments of glasses covering the desired refractive spectrum to determine the refractive indices of batches of Luxorb under preparation. Although the refractive index of a new batch can be predetermined to within a few parts in the third decimal place by closely following the "recipe" for the mixture, variations in raw materials require that final adjustment be made by trial and error.

The prime requisites of optical clarity, good adhesion to glass and excellent attenuation of reflected light, restrict the number of resins, solvent systems, and colorants that can be put into the Luxorb mixture. Present mixtures do not cure by chemical cross-linking (as do the styrenated polyesters, the epoxies, and the urethanes) but are deposited out of solution as the solvent evaporates. Consequently, reasonable care must be taken in applying successive coats to avoid lifting the previously applied film. (In most cases, multiple coats are needed for maximum attenuation.)

Apply with a camel's-hair brush

Luxorb is best applied with a small camel's-hair brush. Small bubbles must be avoided—they produce tiny pinholes and scatter light back into the system. The overcoat may be applied with an air brush. If it is applied by brushing, only one coat is recommended and very light strokes are required to avoid splattering of carbon particles into the primary film, where they would cause undesirable halation effects.

As we've noted, Luxorb is most effective on a polished surface, although true optical flatness is not required. To protect the Luxorb coating, the Nortronics optical shop frequently uses an epoxy resin-Thiokol compound as a sealant and potting agent to mount the coated optical piece in position. This compound gives excellent protection against severe vibration and doesn't attack the Luxorb.

The suppression of off-axis light by the use of Luxorb is considerably enhanced by the proper design of the optical system. Whereas the intensity of an internal beam is attenuated to 10^{-4} or less of its initial value by one contact with the Luxorb-coated surface, multiple reflections reduce the emergent light to an infinitesimal entity (Fig. 4).

The daytime star-tracking capabilities of Nortronics' astro-inertial system are in part due to Luxorb-coated optics. However, the use of these coatings is not restricted to star trackers. We believe that their efficiency in eliminating stray light effects will be equally important in other applications in the broad field of optics. With the continuous development of new polymers and co-polymers, particularly those containing large amounts of halides, the operating range of Luxorb will undoubtedly be extended.—End

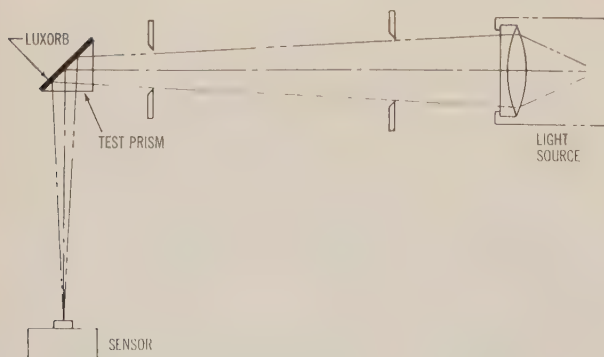
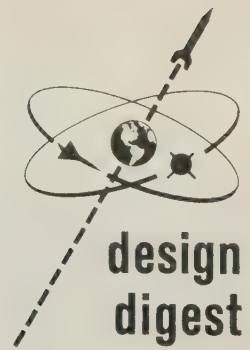
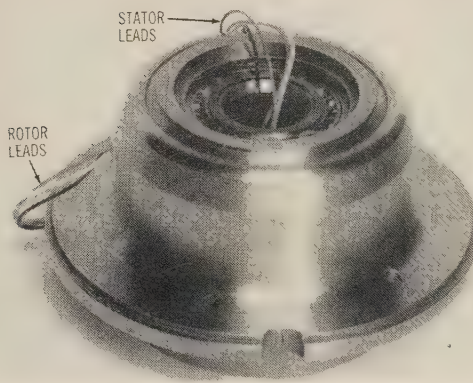


FIGURE 5: Test apparatus for determining the attenuation due to the Luxorb coating.



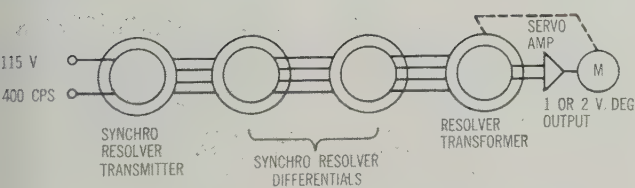
20-sec synchro resolver

supports Polaris platform

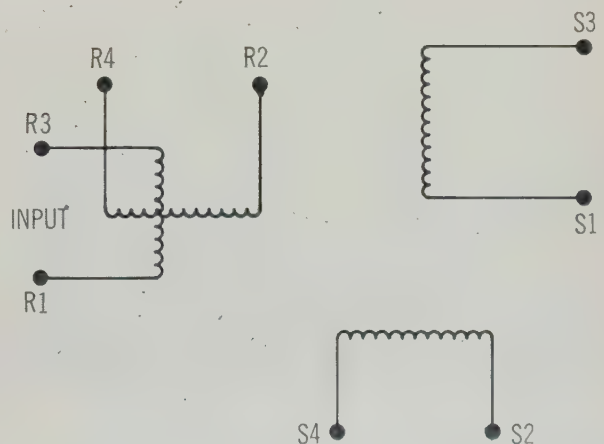


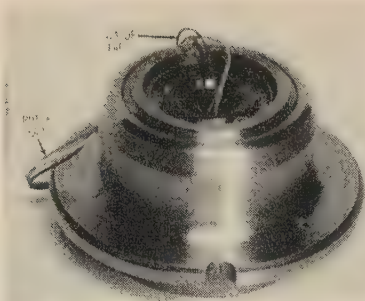
by **Bernard Kovit**
Associate Electronics Editor

TO BRIDGE the gap between conventional wound inductive types of data transmission devices generally used for course positioning, and precise, multi-speed mechanically geared systems, Kearfott Div., GPE Corp., Clifton, N. J., perfected a line of high accuracy synchro resolvers. The extreme accuracy—30 seconds and better—of these devices and their adaptability to resolver transmitter and transformer roles makes possible single-speed data transmission strings with a maximum error of under a minute *without isolation amplifiers*. Biggest push for the synchro resolver came with a contract from GE, Polaris guidance prime, for a precision pick-off to align the sub's inertial platform with SINS. Kearfott has come up with several size 25 units ranging from 20 seconds to five minutes in accuracy for this and other applications in Polaris fire control and guidance. It is working toward a five-sec, single-speed design. Write in No. 56 on Reader Service Card for more data.

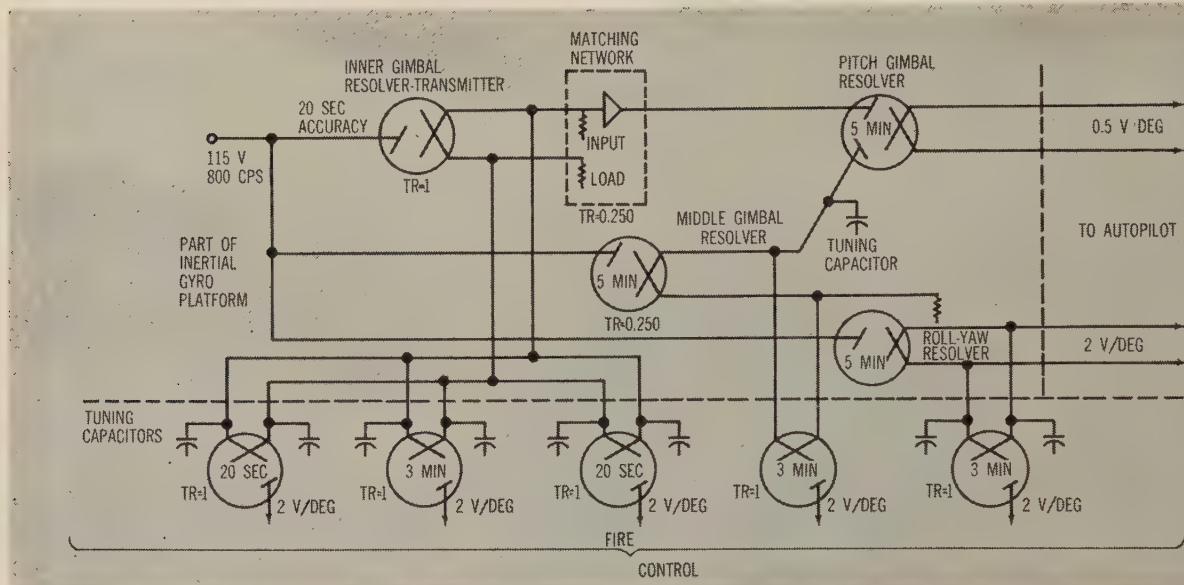
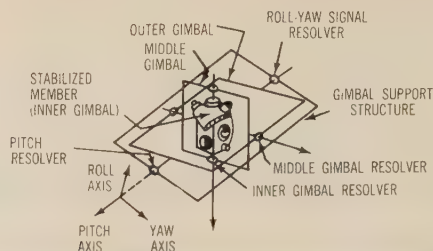


FEASIBILITY of using high-accuracy resolvers in single-speed data transmission systems (above). Reason for using resolver as synchro is that, with simple winding mods, the basic design fits transmitters, differentials, and control transformers. Right: Winding arrangement.



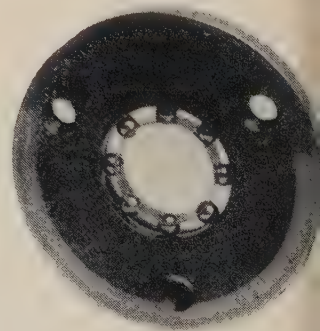
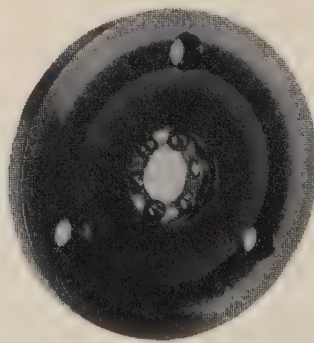
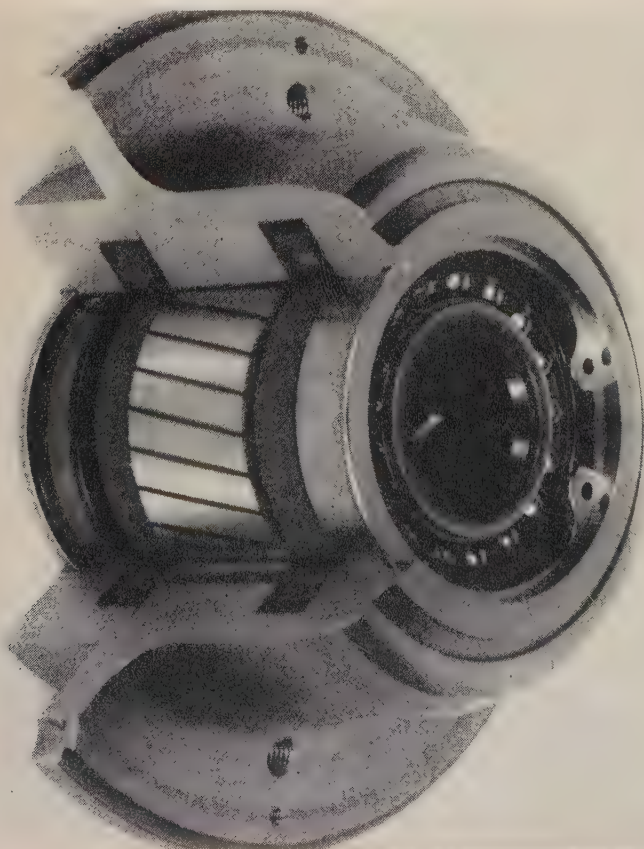


Design Digest (cont.)

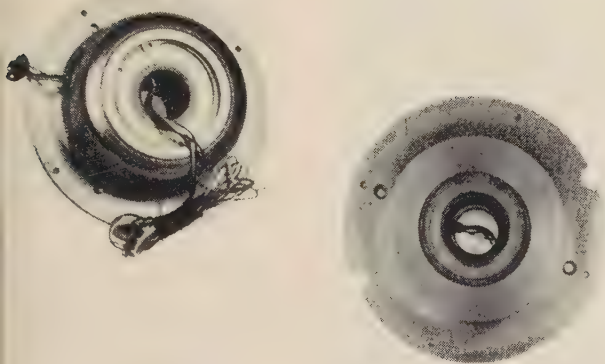


IN POLARIS, hollow-shaft units support the inertial platform and transmit its condition precisely. High-accuracy loops go through 20-sec units. Others carry coarser angle data for discrete computations. Trim capacitors

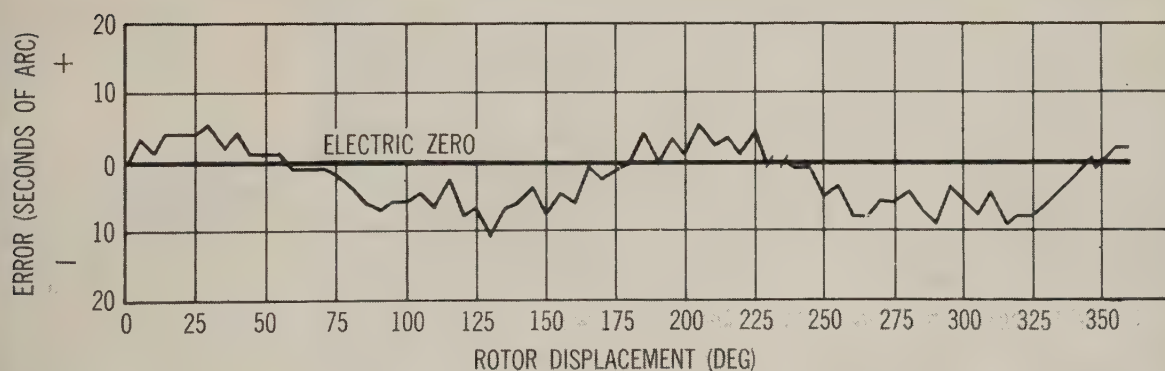
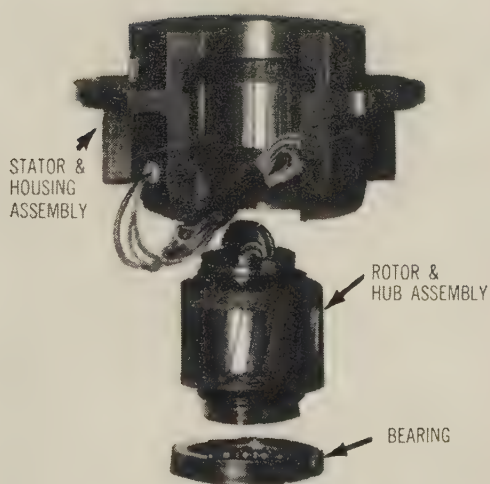
minimize imbalance loads, offset any transient surges due to sudden feedback at launch. Operating range for the high-accuracy resolvers is 25-85 deg C with no more than six per cent error.



RESOLVER control transmitter (left) used as precision pick-off in aligning Polaris platform to SINS (shipboard inertial navigation system). Kearfott placed great emphasis on perfecting bearings (above), since 1500 lb radial and 200 lb thrust must be handled by the inner and 200 lb radial and 4800 lb thrust by the outer without degrading accuracy.



TOP AND BOTTOM views. Tolerances used for bearing runouts run about 30 millionths of an inch. Mounting-surface perpendicularity is critical, since unit must attach to middle gimbal and accept shaft of inner gimbal. Right: Partially exploded view of gimbal-mounted unit.



TYPICAL ERROR CURVE shows 10-sec performance. Kearfott engineers believe a five-second, single-speed unit is at hand, but that it would take 0.5-sec equipment to test it. They stress that the extreme accuracies have come about mainly through finer manufacture.

Electric Data for 20-Sec Resolver

Excitation voltage	115 V
Frequency	800 cps
Input current	127 ma
Transformation ratio	1.0160
Phase shift	0.8 deg
DC resistance	
Rotor	20.55 ohms
Stator	21.22 ohms
Total null voltage RMS	25 mv
Fundamental null voltage	18 mv

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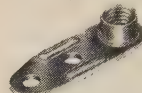
with an eye to "trimming off the fat." See for Kaynar's new full-line brochure of 16 self-locking nuts.



H14 6-point Hex Nut



MF1400 Floating Anchor Nut



K2400 1-Lug Anchor Nut



MK1400 2-Lug Anchor Nut



F2400 1-Lug Floating Anchor Nut



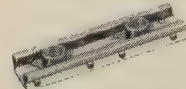
F5400 2-Lug Floating Anchor Nut



K1400 2-Lug Anchor Nut



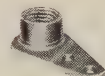
MK4400 Short Lug Anchor Nut



G1400 Narrow Gang Channel



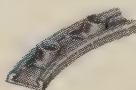
K3400 Corner Anchor Nut



MK2400 Miniature 1-Lug Anchor Nut



MK3400 Corner Anchor Nut



RG1231 Radius Gang Channel



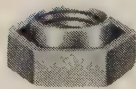
H23 12-Point High Tensile Nut



H20 12-Point High Tensile Nut



H24 12-Point High Tensile Nut



H10 6-point Hex Nut

TENSILE STRENGTH
H10 meets requirements of MIL-N-25027, AN-N-10 (NAS 6364, 365) (MS) for use on 125,000 psi and screws.

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MF1400	550°F.	160,000psi.	C
K2400	550°F.	160,000psi.	C
MK1400	550°F.	160,000psi.	C
F2400	550°F.	160,000psi.	C
F5400	550°F.	160,000psi.	C
K1400	550°F.	160,000psi.	C
MK4400	550°F.	160,000psi.	C
G1400	250°F.	160,000psi.	Nu Ch
K3400	550°F.	160,000psi.	C
MK2400	550°F.	160,000psi.	C
MK3400	550°F.	160,000psi.	C
RG1231	1,200°F.	160,000psi.	C
H23	550°F.	180,000psi.	A
H20	550°F.	180,000psi.	A
H24	550°F.	220,000psi.	A
H10	550°F.	125,000psi.	C

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Finding the characteristics of artificial atmospheres

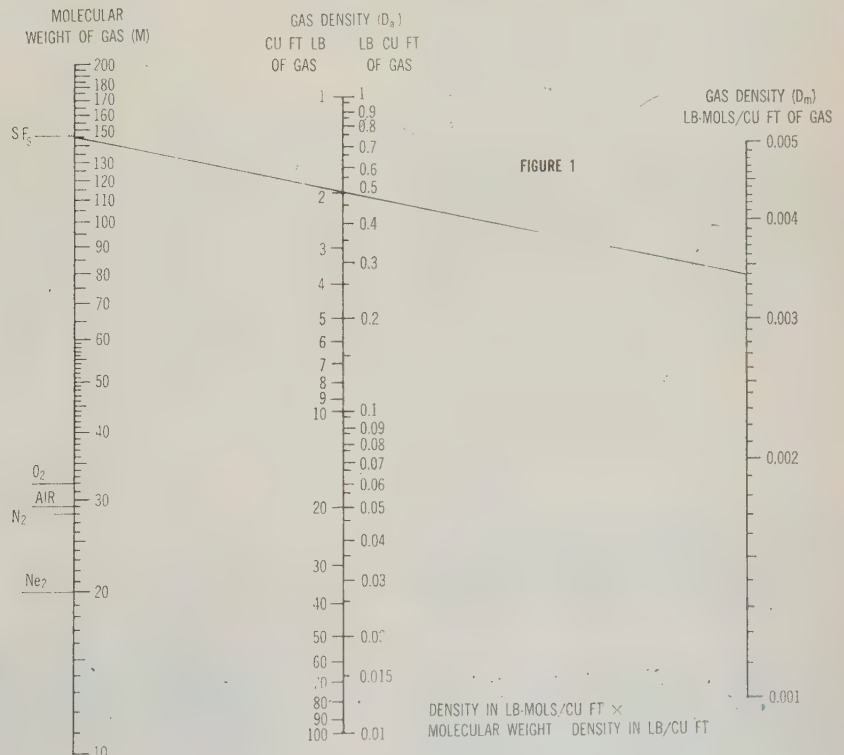
Among the new problems confronting the designer of upper-atmosphere and space equipment is that of monitoring the densities and pressures of artificial atmospheres. The nomographs presented here, which were developed by members of the engineering staff of Newark Controls Co.,* make it easy to determine these parameters.

WITH these nomographs, the designer engineer can readily compute temperatures, pressures, and gas densities for the atmosphere (air, nitrogen, sulphur hexafluoride, and fluorochemicals) used for electric insulation (to prevent arc-over) and heat dissipation in closed or sealed assemblies of upper-atmosphere and space equipment. They can be applied if two factors are known and the gas approximates the perfect gas law ($PV = nRt$).

* Newark Controls Co., Bloomfield, N. J.

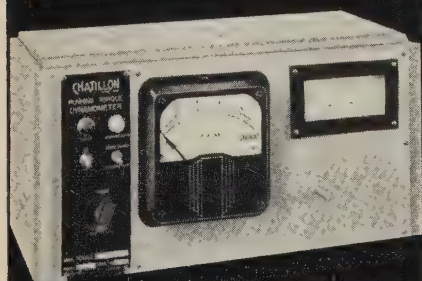
more on page 166

FIGURE 1: Nomograph for $D_m M = D_a$, where M is the molecular weight of gas; D_m , the density of gas in lb-mols/cu ft; and D_a , density in lb/cu ft. You first locate the molecular weight of a gas on the M -scale, then locate the density of the gas on the D_a -scale, and finally extend a straight connecting line between the points on these two scales to the D_m -scale.



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ATMOSPHERES . . .

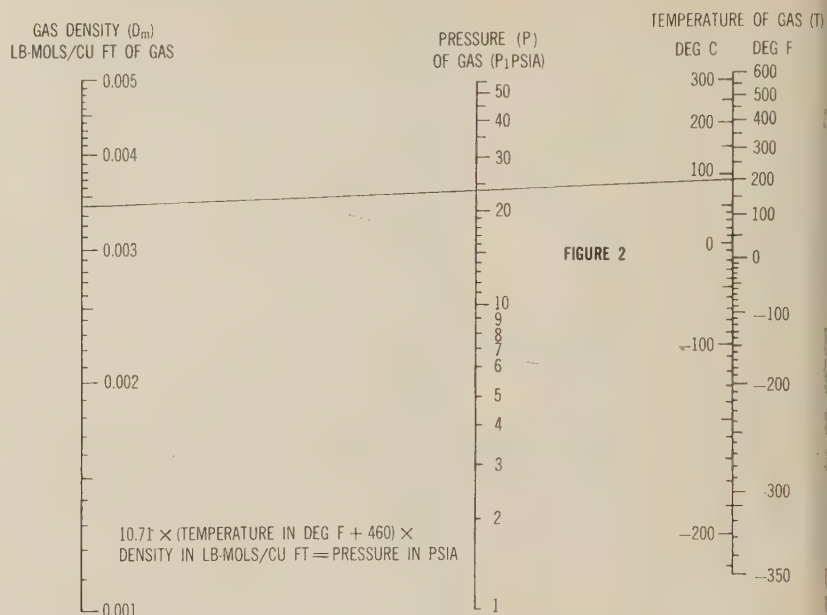


FIGURE 2: Nomograph for finding the absolute pressure (P) of an artificial atmosphere.

Sample Problem—If a sealed container is filled with 0.5 lb/cu ft of sulphur hexafluoride (SF_6), what will be the pressure of the gas at 200 deg F?

First you find the density of the gas in lb-mols/cu ft. For this you must know the gas's molecular weight and density (in lb/cu ft). Both these values are plotted in Figure 1, which represents the equation:

$$D_m M = D_a$$

where M is the molecular weight of gas; D_m , the density of gas in lb-mols/cu ft; and D_a , density in lb/cu ft.

The procedure for using Figure 1 is:

- (1) Locate the molecular weight of the gas (SF_6) at 146 on the M -scale.
- (2) Locate the density of the gas at 0.5 on the D_a -scale.
- (3) Extend the straight connecting line between these two points to the D_m -scale and read the gas density as 0.0034 lb-mols/cu ft.

Now we can find the pressure of

the gas at 200 deg F by using Figure 2. This nomograph represents the equation of the perfect gas law:*

$$P = 10.71 T_{\text{degR}}, P = 19.3 T_{\text{degK}} D_m$$

where T_{degR} is temperature in degrees; T_{degK} , temperature in degrees; and P , absolute pressure (in psi).

The procedure for using Figure 2 is:

- (1) Locate 0.0034 on the D_m -scale.
- (2) Locate 200 deg F on the T -scale.
- (3) Connect these two points with a straight line and read 24 psia at the intersection with the P -scale.

Conversely, if the temperature and pressure of a given gas were known, it would be quite easy to find the density of the gas in lb-mol/cu ft.—End

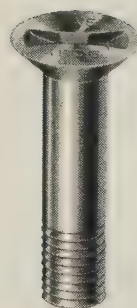
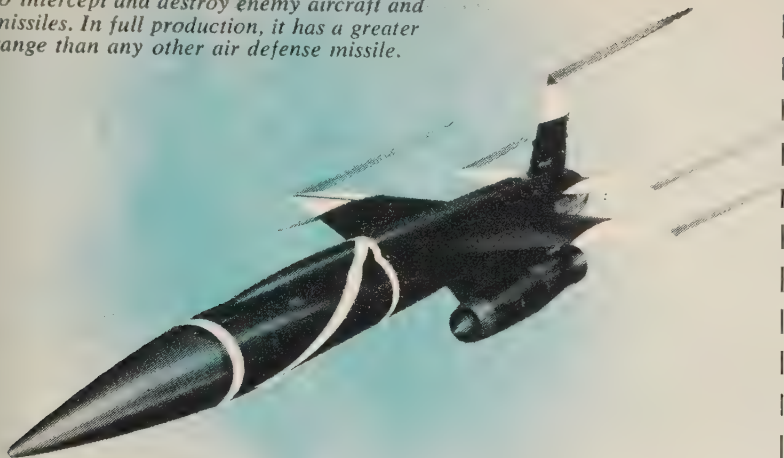
* The value 10.71 is the universal gas constant in psi, cubic feet, and degrees R. It represents two-thirds of the translational kinetic energy of one mole (mol) of gas per degree of absolute temperature and is derived from Avogadro's number of 2.75×10^{26} molecules per pound-mole. The value 19.3 is the universal gas constant in psi, cubic feet, and degrees K.

Beryllium Rotor for Gyro

An electronically suspended beryllium rotor is the key element of a new two-axis-displacement electrostatic gyro in development at Minneapolis-Honeywell Regulator. The beryllium sphere, machined to a tolerance of 0.000015

in., rotates at high speed in a vacuum. M-H believes this design will produce less drift than conventional gyros. The main applications of the new unit apparently would be in long-time-of-travel inertial systems.

THE BOEING IM-99 BOMARC is a long range, extremely high altitude supersonic missile designed to intercept and destroy enemy aircraft and missiles. In full production, it has a greater range than any other air defense missile.



HI-TORQUE BOLT

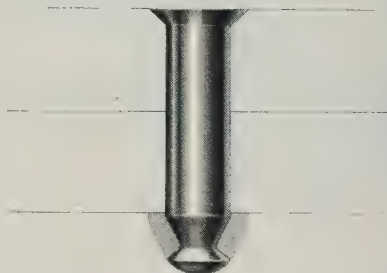
IDEAL FOR FASTENING STRESSED ACCESS AND CLOSE-OUT PANELS. ITS UNIQUE SHALLOW RECESS LOCKS THE DRIVER INTO IT WHEN A HIGH TORQUE LOAD IS APPLIED DURING INSTALLATION OR REMOVAL.

STRUCTURAL EFFICIENCY CONTRIBUTES TO GREATER PERFORMANCE

The airframe of the Bomarc reflects a successful solution to structural and fastening design problems typical to high performance missiles and aircraft. The airframe combines high strength with high temperature resistance, without adding unnecessary weight which could effect performance.

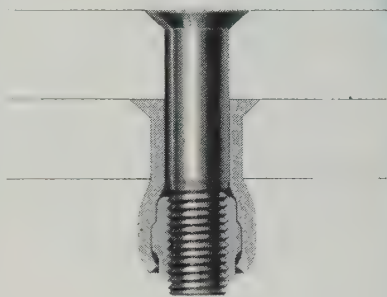
Three different fastener problems in the Bomarc are solved by stainless steel Hi-Shear fasteners. Hi-Shear Rivets are used in structure subjected to engine and rocket boost heat... Hi-Torque Bolts fasten removable panels and the nose section where heat, surface smoothness and ease of removal are factors. Blind Nuts eliminate hole/nut coordination problems in congested areas.

Continuing fastener environmental studies are being conducted at the Hi-Shear Test and Research Laboratories in a variety of strength and temperature resistant material combinations for advanced structural requirements.



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HAS THE LIGHTEST STRENGTH-WEIGHT RATIO, LEAST PROTRUSION AND LOWEST COST OF ANY SWAGED TYPE FASTENER. INSTALLED WITH STANDARD RIVET GUNS OR SQUEEZERS FITTED WITH HI-SHEAR RIVETING SETS.



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FOR BLIND OR OPEN APPLICATIONS, THE BLIND NUT CUTS PRODUCTION COSTS BY USING ONE HOLE INSTEAD OF THE NORMAL THREE REQUIRED FOR NUTPLATES. INSTALLATION SPEED IS ABOUT TEN PER MINUTE BY ONE MAN USING A LIGHTWEIGHT, HYDRAULICALLY OPERATED GUN.

U.S. PATENT PENDING, FOREIGN PATENTS GRANTED AND PENDING

"HI-TORQUE" TRADEMARK REGISTERED IN U.S. PATENT OFFICE
U.S. PATENTS NO. 2,877,885; 2,745,120 AND 2,792,039
U.S. PATENT PENDING.

"HI-SHEAR" TRADEMARK REGISTERED IN U.S. PATENT OFFICE
U.S. PATENTS NO. 2,355,879; 2,555,980; D-128-879.
OTHER U.S. AND FOREIGN PATENTS PENDING



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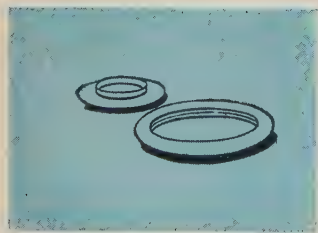
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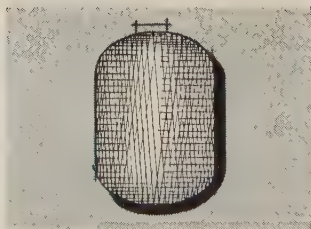


At Garlock, delivery of high quality rocket motor components in the shortest time is of prime importance. To meet this objective, research and development, product design, tool design, pilot manufacturing, and production staffs work together as a fully integrated team. By solving problems of design and production jointly, they avoid time-consuming redesigning and retooling.

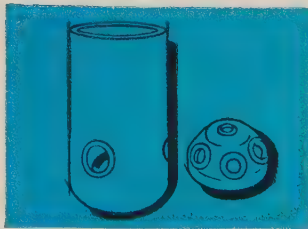
Flexible, Diversified . . . Garlock will swing into prototype production on short notice and follow this with full scale production as needed . . . will design and manufacture rocket motor components from a variety of basic materials—rubber, metals, phenolics, fluorocarbon plastics.



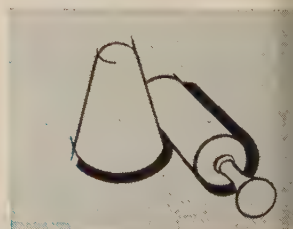
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- Polaris
- Minuteman
- Super Vanguard
- Terrier
- Nike Hercules
- Super Tartar



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SPACE/AERONAUTIC

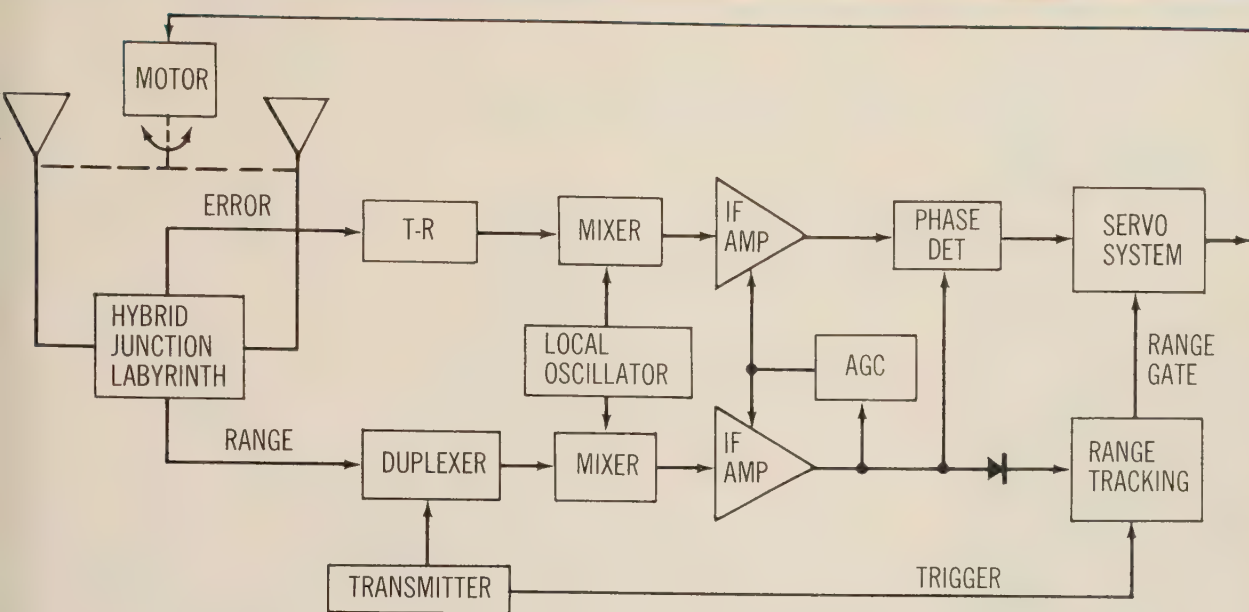


FIGURE 1: Basic monopulse radar with a single coordinate channel for either phase or amplitude comparison.

Single radar echo pinpoints targets

With the development of the monopulse concept, a new chapter began in tracking-radar theory. The concept is equally applicable to direction-finding, passive homing for missiles, and even stereophonic sound recording.

by **Dean B. Anderson**, Senior Technical Specialist,
Preliminary Engineering Section, Armament Control Engineering,
Autonetics Div., North American Aviation, Inc.*

DURING World War II, when conical scan radars were in the "breakthrough" stage, it was observed that target amplitude fluctuations at or near the lobing frequency caused errors in the tracking signal. These fluctuations

—due to changes in reflections from the target, interference, jamming and/or noise—adversely affected conical scan systems, because these tracked by sequential lobing. They therefore depended on the comparison of target returns with others, previously received returns, and differences in signal

amplitudes during a sampling interval led to the wrong angular information.

It wasn't until the microwave hybrid junction had been developed that designers were able to come up with a new method of angle tracking that was impervious to target amplitude changes. This method overcame the fluctuation problem quite simply: It extracted coordinate information from a *single radar echo*.

Bell Labs, one of the research groups then working on tracking radars, coined the name "monopulse" for the new technique. Less commonly, this technique is also known as "simultaneous lobing,"

more on next page

*Autonetics Div., North American Aviation, Inc., Downey, Calif.

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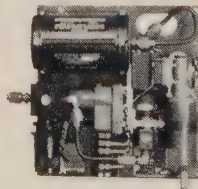
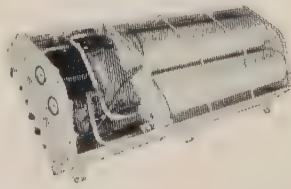
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RADAR ECHO . . .

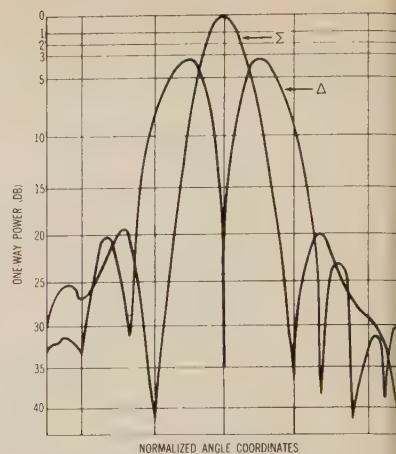


FIGURE 2: Typical monopulse sum and difference pattern.

to distinguish it from "sequential lobing".

After World War II, two types of monopulse radar were put into operation almost simultaneously—one worked on the phase-comparison principle, the other on amplitude comparison. Walter Hausz of General Electric was responsible for the former and R. M. Page of the Naval Research Lab for the latter. In design and operation, these two types of monopulse radar are almost identical. The main difference between them lies in the construction of the antenna system.

The phase-comparison system normally uses physically separated antenna apertures whose radiated beams are aligned or collimated. The target echoes received in the aperture are, therefore, of equal magnitude regardless of the target's angular position relative to the radar beam.

However, because the phase centers of the apertures are physically separated, each antenna at a given instant sees a different phase of the signal wavefront. The angle of arrival of the echo can therefore be measured by comparing the phases of the microwave energy received in each aperture. This interferometry technique is now widely applied in radio astronomy and satellite tracking.

In the amplitude-comparison scheme, two antenna apertures are arranged so that they produce "Squint", causing the beams to cross over near the half-power level. The apertures are usually combined to have the same phase center, so that the angle of arrival of the echo is determined by an

more on page 172

SPACE/AERONAUTICS

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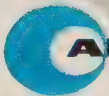
Aeronca produces the precision parabolic radar reflectors as a D-T-P* "envelope" project, on a subcontract basis. Highly specialized skills and facilities are required to meet their stringent specifications.

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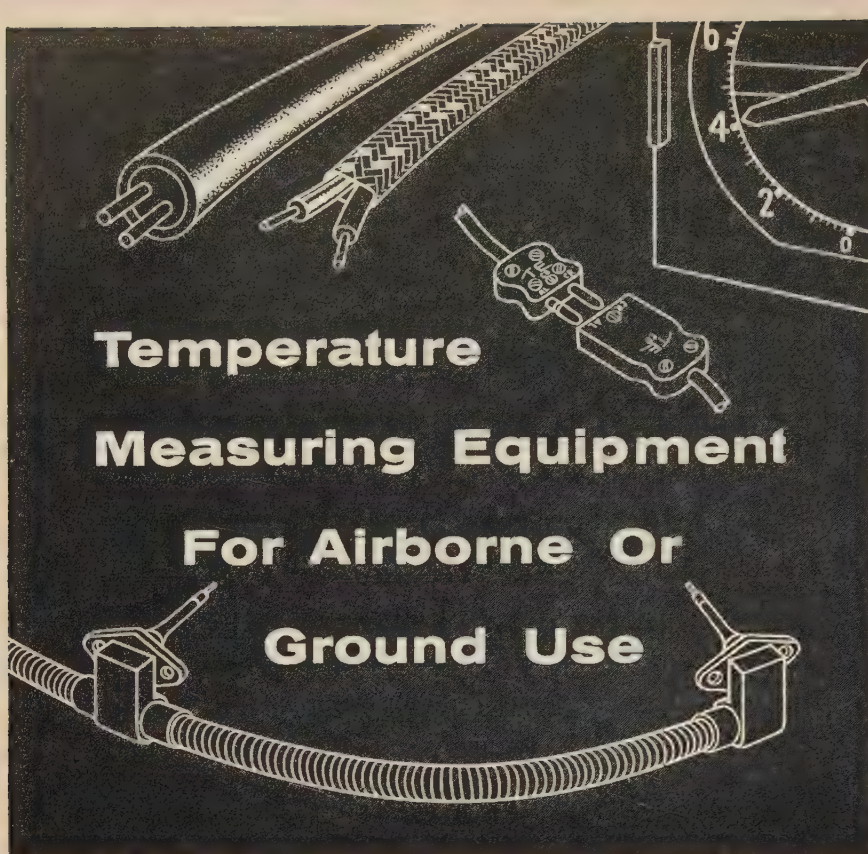
Engineers and Scientists — Such programs reach far into the future and deal with unknown and stimulating environments. It is a rewarding future with a company that has an outstanding record of progress and achievement. If you are experienced in any of the above areas, or in related work, we invite your inquiry. Please write: Research and Development Staff, Dept. A-16, 962 W. El Camino Real, Sunnyvale, California. U.S. citizenship required.

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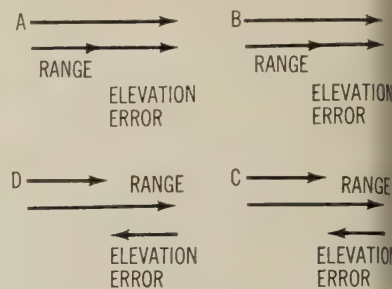
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RADAR ECHO . . .

ELEVATOR ERROR (TARGET UP)



AZIMUTH ERROR (TARGET RIGHT)

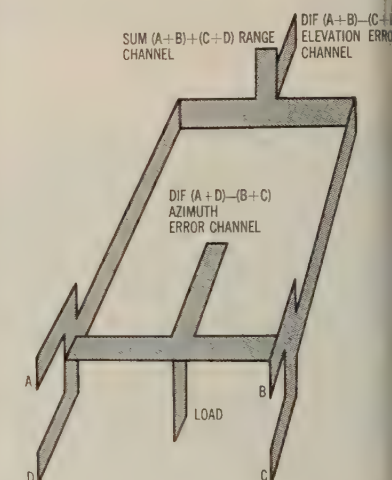
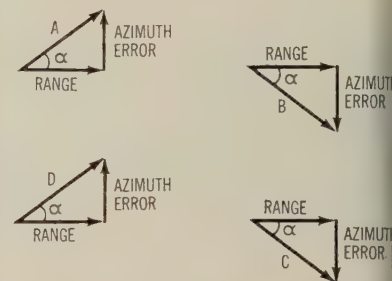


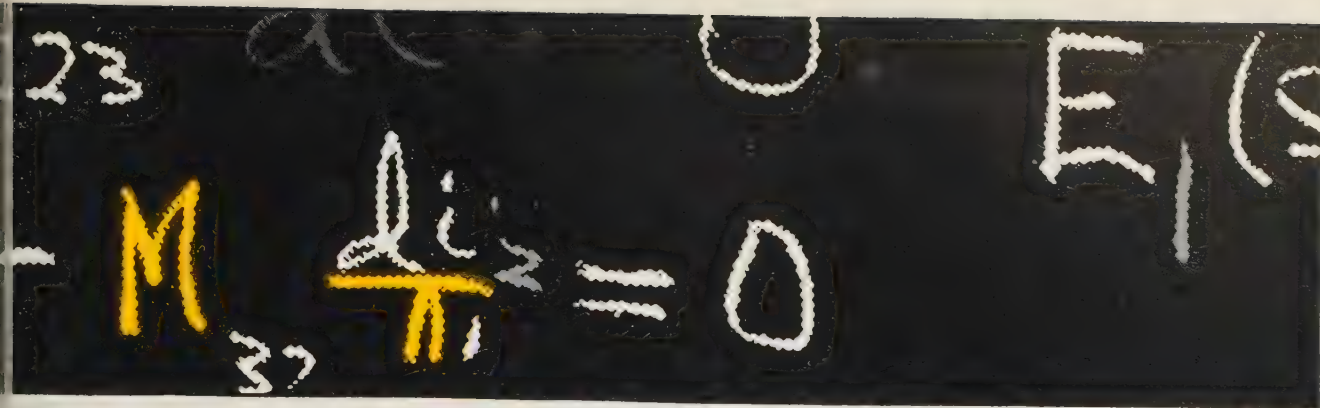
FIGURE 3: Vectors (top) of a two coordinate amplitude and phase comparison system. Bottom: Microwave labyrinth of four conventional magic Ts used to separate sum and differences of signals received on four feed horns.

amplitude comparison of the energies received by the two aperture

In both amplitude and phase systems, a microwave labyrinth of hybrid junctions couple the energies appearing on the aperture terminals to derive signals representing the vector and sum difference (Fig. 2).

In an amplitude-comparison system, the sum, or range, signal is either in or out of phase with the difference, or error, signal. In a phase comparison, the range and

more on page 1



General Motors pledges

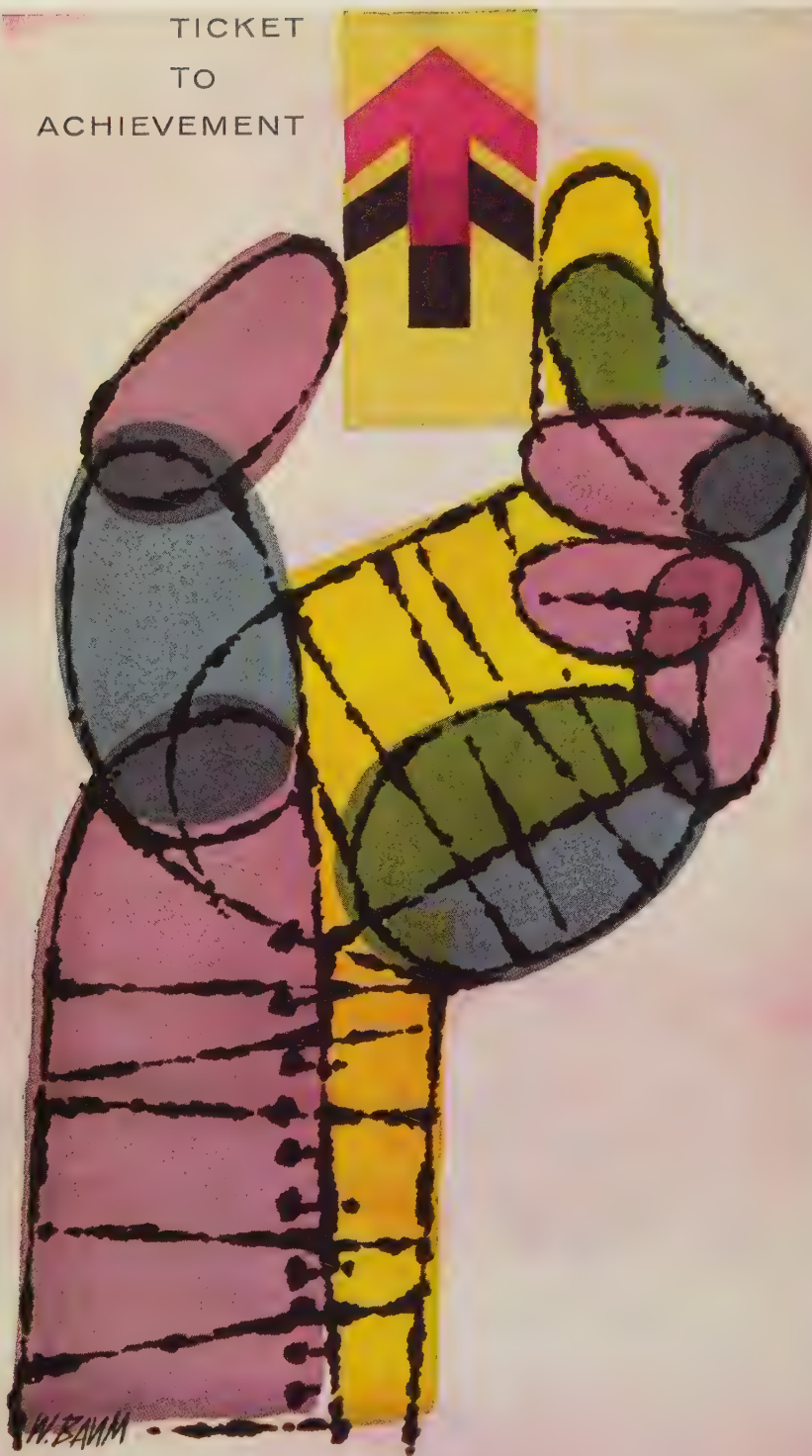
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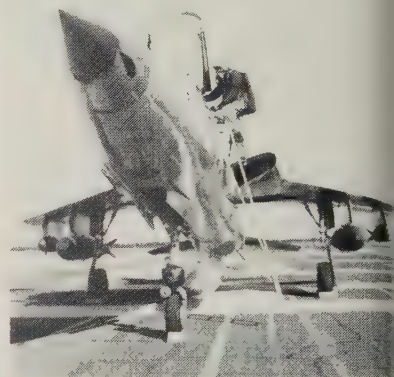
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RADAR ECHO . . .



ALL-WEATHER version of Republic F-105 Thunderchief fighter bomber will be equipped with monopulse tracking radar designed and built by Autonetics.

error signals are in phase quadrature. These signals are converted to an intermediate frequency for amplification (Fig. 1).

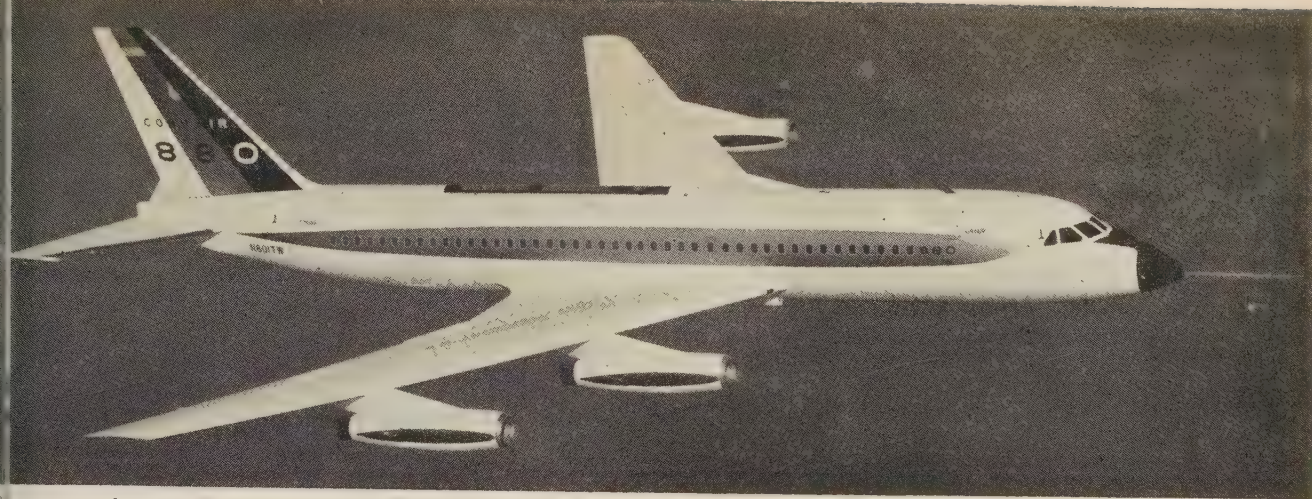
The radar transmitter pulse is injected into the sum channel through a duplexer to illuminate the target. The sum, or range, signal is amplified, detected, and applied to the range tracking circuitry in the usual manner. The error-channel signal is amplified and applied to a phase (or product) detector. The phase reference signal for this detector is provided by the range channel.

A common method of making the angular error signal independent of target range and size is to apply sum-channel automatic gain control voltage to the error-channel amplifiers thus normalizing the angle signal (Fig. 2).

For two coordinates (azimuth and elevation) any combination (amplitude-amplitude, phase-phase, or amplitude-phase) may be selected. The microwave labyrinth for a two-coordinate system requires four microwave hybrid junctions. Only one hybrid is needed for a single coordinate. It is possible, however, with just a single hybrid and an ingenious arrangement of the antenna apertures, to obtain a two-coordinate phase and amplitude system wherein the azimuth and elevation information is derived in time quadrature.

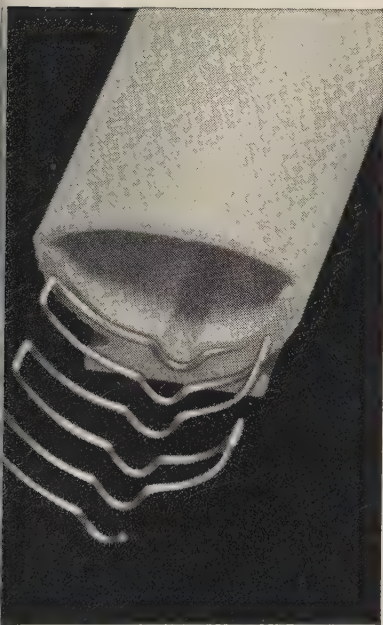
The monopulse principle may be applied to any type of antenna aperture: parabolic reflectors, lens,

more on page 178

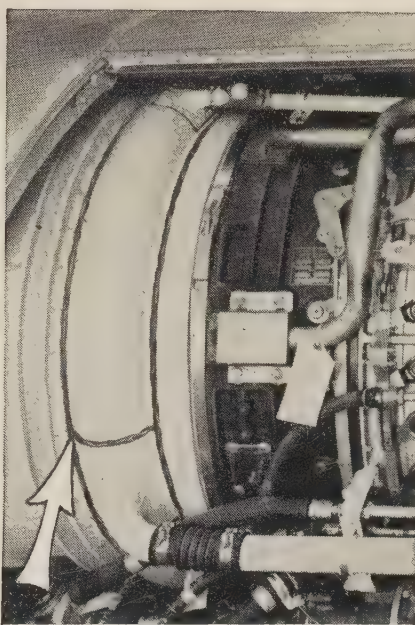


support door seal designed by Convair is typical of advance design features of the 880. General Electric silicone rubber—its outstanding resistance to temperatures, ozone and aging—is used extensively on the General Dynamics Convair 880.

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Unique silicone rubber door seal incorporating spring steel flex-support, fail safe feature that eliminates the danger of seal collapse. General Electric SE-555, with twice the strength of ordinary silicone rubber, easily withstands flexing of integrally molded steel support. Over 600 wiping action and pressure cycling tests prove seal will meet all operational requirements.



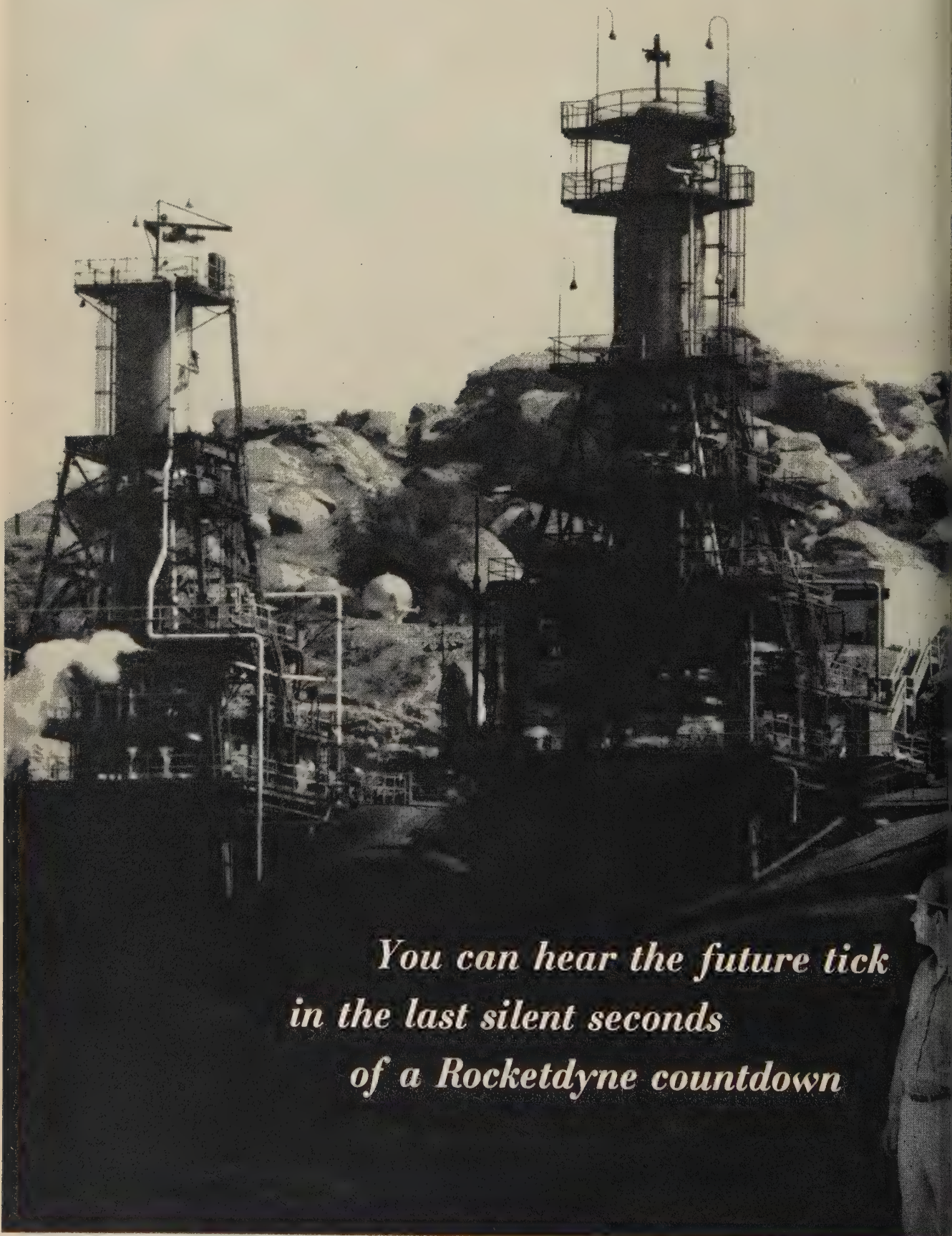
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GENERAL ELECTRIC

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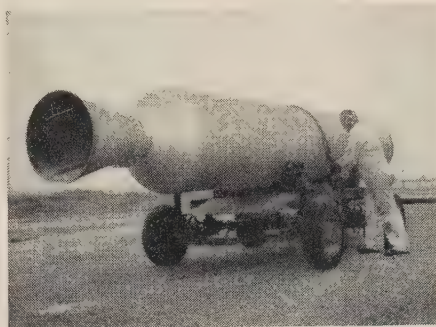
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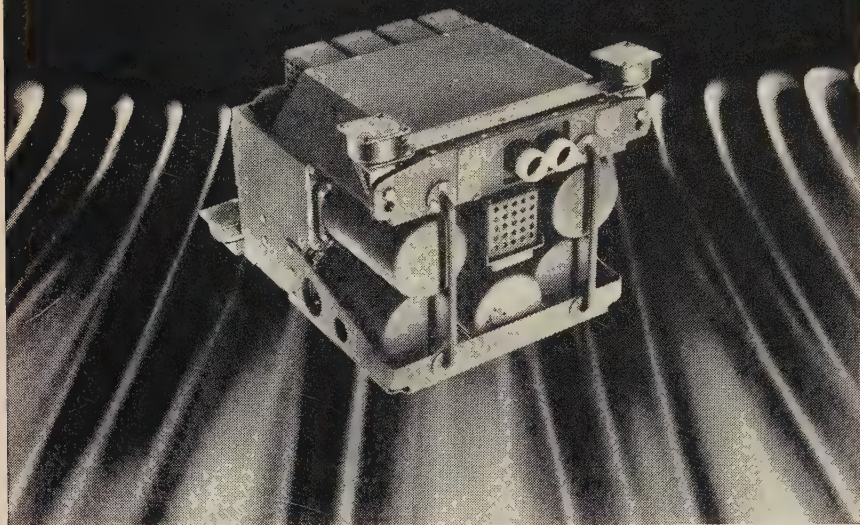
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RADAR ECHO . . .

horns, slot arrays, spirals, etc. Similarly, the microwave labyrinth may be made of any type of hybrid junction: magic-T, rat-race, short-slot couplers, etc.

Figure 3 shows the vectors of a two-coordinate amplitude and phase comparison system for determining azimuth and elevation angles. Two parabolic reflectors placed side by side, each fed at the focus, and aligned to collimate their beams are phase-difference-sensitive to angular deviations in the azimuth plane.

Two additional horns displaced in elevation from the focus to produce squinted beams also illuminate the reflectors and are amplitude-difference-sensitive to elevation angle divisions. These four feeds—two illuminating each reflector—are connected by the waveguide labyrinth made up of four conventional magic Ts.

Figure 3 also shows the vector relationships of energy in each feed for both a pure azimuth error and a pure elevation error. The system has elevation and azimuth radiation patterns similar to those of Figure 2.

The elevation error signal will be either in or out of phase with the range signal, while the azimuth error signal will be in time quadrature with the range signal. Three IF amplifiers and two product detectors activate the antenna servo in azimuth and elevation.

The sum-difference form is preferable

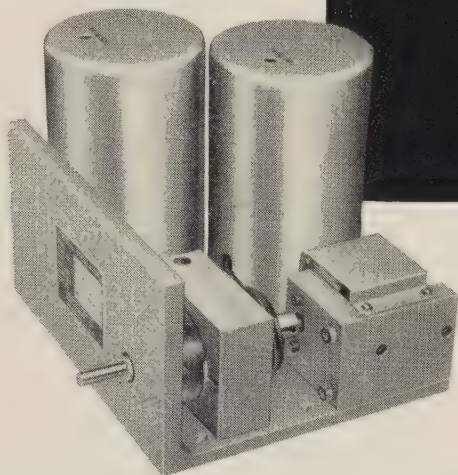
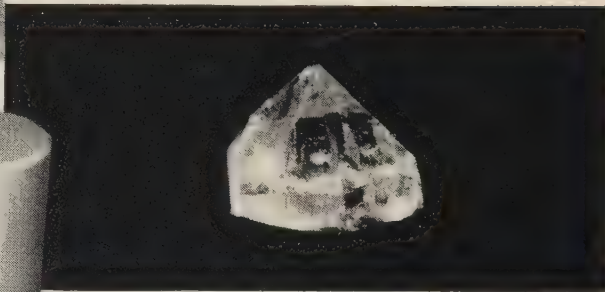
The geometric form of the antenna aperture determines whether angular sensing depends on phase or amplitude. Either may predominate, but not to the absolute exclusion of the other. The waveguide labyrinth may transform either type into the other or into a third—sum-difference.

The sum-difference form is preferable, since it minimizes the effect of imperfect transmission through rotary joints, duplexers, mixers and the IF stages on boresight stability. The reason why imperfect differential transmission through any of these components of either phase or amplitude data materially affects system boresight is that the actual boresight line is indicated by equal signals in both phase or amplitude. In the sum-difference form, the effect of asymmetries is minimized because

more on page 18



Enlarged photograph of raw crystal



BULOVA CRYSTAL CONTROLLED ULTRA-STABLE SHIFT OSCILLATORS

Crystal shift oscillators are all that any electronics engineer asks for in miniature crystal controlled packages!

Order this new Bulova custom designed 18.5mc shift oscillator. Here's an assembly of two oscillators operating at 18.5mc. One is fixed, with a $1 \text{ pp } 10^7$ stability. The other is variable with equal stability, $1 \text{ pp } 10^7$. The shift is accomplished by means of a variable air capacitor. How-

ever, the same shift, at the same frequency, can be affected with a "Varicap*".

This new ultra-stable shift oscillator is only one of many recent advances made by Bulova Electronics. For information on these specific units, or on how Bulova experience, in mastering component and system reliability, can help your program, write—

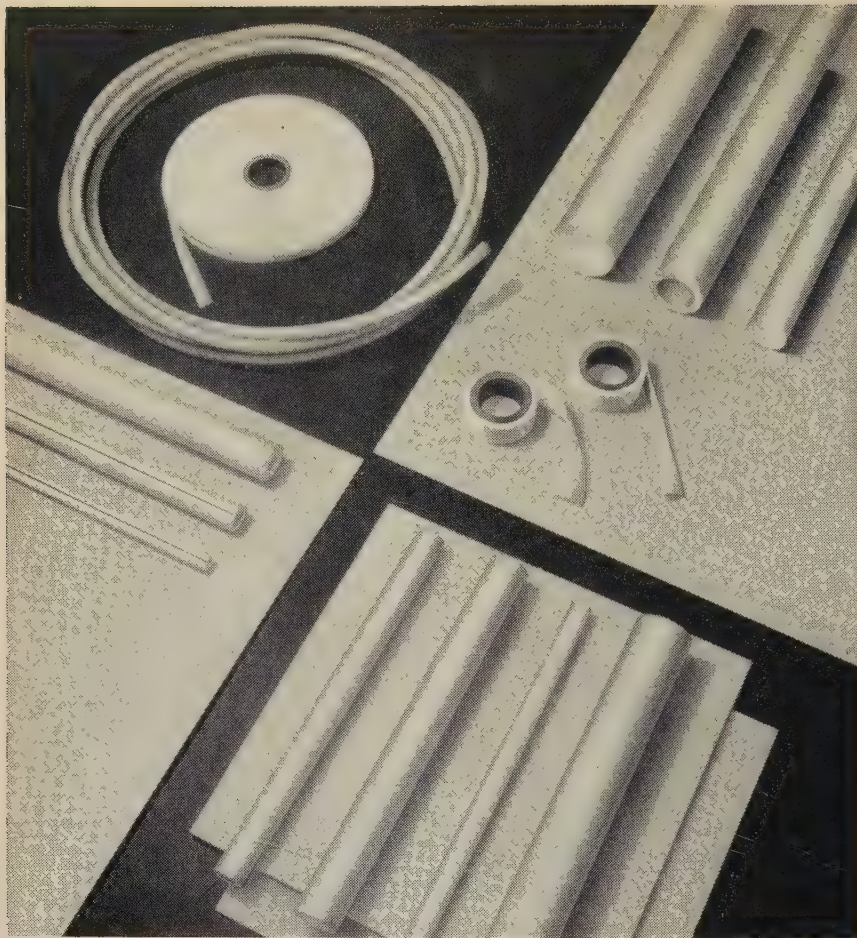
Department A-1361, Electronics Division, Bulova, 40-06 62nd Street, Woodside 77, New York

*TM: Pacific Semiconductor, Inc.



BULOVA

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Critical electrical parts in high-heat environments are typical applications for "Teflon" — a vital material which R/M specialists can best fabricate into the forms you need and deliver according to your schedule. New bondable R/M "Teflon" further increases applications in the aeronautics field.

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No need to restate the unique combination of electrical, chemical and physical properties of "Teflon." You know that for many aircraft and missile parts calling for high dielectric strength and heat-resistance, there simply is no substitute.

Your main concerns with "Teflon," then, are *where to get it fast and who can best meet your specs.*

On both counts, the answer is R/M. A pioneer in the processing of "Teflon"

into sheets, rods, tubes, tape, hose and other machined parts, R/M offers you a *complete "Teflon" service* — a service that can help assure you optimum performance and reliability of critical components.

It will pay you to talk "Teflon" with R/M. Call your nearest R/M district office (listed below) or write Plastic Products Division, Raybestos-Manhattan, Inc., Manheim, Pa.

*Registered trademark for Du Pont fluorocarbon resin



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amplitude and phase comparison is done by the hybrid junctions.

Angular-magnitude information is contained solely in the error signal amplitude, while the angular sense information is contained in the error signal phase measure relative to the sum signal.

The microwave signals in both channels heterodyned by a common local oscillator to an intermediate frequency for amplification. The common oscillator preserves the differential phase coherence. After amplification, the signal is prepared for the servo by an angle detector that determines the mathematical functional form of the angle signal. Some type of product of phase detector is normally used for this job.

Amplitude and phase imbalance in the antenna, labyrinth, IF amplifiers, or product detectors can contribute to boresight shifts. In typical systems, antenna and microwave labyrinth must be balanced within 0.3 db in amplitude and three degrees in phase. These stringent limits make it possible to relax the amplitude and phase tolerance in the active circuits to some extent without appreciable boresight errors.

A good figure of merit is available

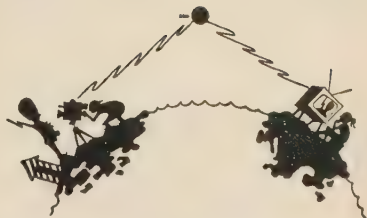
An excellent figure of merit for any component or the entire system is the error channel null depth at the boresight. Typical figures are in excess of 30 db. Undesirable cross-coupling terms and asymmetries are the chief sources of energy that fills in this boresight null.

The first waveguide labyrinth were complicated affairs. Today Autonetics has successfully compressed wide-band, high-power waveguide labyrinths to a volume of less than three cubic wavelengths.

With simultaneous lobing you can in theory track a target to any degree of precision—provided the single-to-noise ratio is high enough, the system boresight null is sufficiently low, and the target is in the Fraunhofer (far-field) zone. Atmospheric inhomogeneities place an upper limit on precision. The angular sensitivity is proportional to the aperture spacing in a phase system, while there is an optimum squint for maximum angular sensitivity in the amplitude system.

more on page 11

How a
communications
satellite can
bring you *live* TV
from anywhere
in the world



World-wide live TV, with no cable or radio relay costs, can develop from outer-space research by government and industry

Among the peaceful applications for scientific break-throughs being made in the study of outer space is a communications satellite.

Using inflated plastic satellites, boosted toward orbit by the Air Force *Thor* rocket, a global TV network could be established. TV signals would bounce to satellite and back to your station, giving you a front-row seat at events anywhere in the world. Cost should be a fraction of coaxial cables and microwave relays now used.

Practicality of *Thor* for this purpose is based on its demonstrated reliability. With Douglas responsible for airframe fabrication and assembly and test of the entire system, *Thor* has helped launch 84% of all payload weight put into space by the U. S.; is the key booster in the Air Force "Discoverer" firings; launched the first nose cone recovered at ICBM range.

Thor is another product of the imagination, experience and skills which Douglas has gained in nearly 20 years of missile development.

Foil-covered satellite, folded like a pocket raincoat, would balloon out in orbit as an inexpensive TV relay station

DOUGLAS



Builders of the
DC-8 Jetliner

MISSILE AND SPACE SYSTEMS • MILITARY
AIRCRAFT • TRANSPORT AIRCRAFT •
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New Titanium alloy takes the

...in strength...in weight...in reliability...in price

Titanium rocket-motor cases can be built at least 30 percent stronger (or lighter) than best available alternate metals; provide permanent corrosion resistance without protective coatings; withstand temperatures from -400°F to $+800^{\circ}\text{F}$; will not absorb moisture which distorts critical parts in storage.

Completed assemblies give a spectacular two-way pay-off . . . immediately; provide a growth potential virtually unlimited.

The alloy: Ti-13V-11Cr-3Al, the beta titanium alloy. Now available from Titanium Metals Corporation of America at commercial lead-times (billet, 2-3 weeks), beta may well become the metals story of the year.

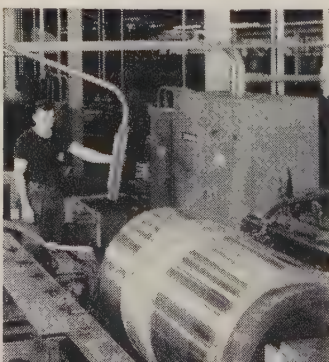


Welding of titanium at P&WA is based on the company's experience in production of more than 5800 jet engines containing titanium parts. Weld strength of beta titanium alloy is considerably improved by cold working the weld.

End Closure Titanium Forgings produced by Wyman-Gordon Company and machined by P & WA, will be girth welded to the flow-turned cylinders. Bosses are an integral part of the closures.



Flow-turning from roll-forged rings, makes feasible production of full-scale titanium rocket cases, since it yields integral cylinders, eliminates need for longitudinal welds, conserves input metal.



Pilot rocket-motor cases manufactured by Pratt & Whitney Aircraft from beta titanium alloy Ti-13V-11Cr-3Al have been consistently burst tested at levels in excess of 235,000 psi — a burst strength/density ratio of 1,340,000.

So successful has been its titanium program that Pratt & Whitney Aircraft considers the production of full-scale titanium cases can be easily realized. Estimated initial burst strength is a conservative 180,000 psi — a burst strength/density ratio of 1,000,000. Readily attainable is 1,250,000.

Reasons for optimism, spelled out by P&WA engineers are:

1. "The welded beta titanium alloy is capable of considerable plastic deformation prior to rupture. As welding has improved, the failure origins have moved into the thin wall (of the case itself). With beta titanium, the case tears but doesn't fragment.
2. "We have successfully tested small scale titanium cases with a steel equivalent yield strength well beyond the 300,000 psi point. Considering the metallurgy of metastable beta titanium alloy is not far beyond its infancy, conservatively one would predict strengths substantially higher than the 320,000 psi equivalent as being quite possible.
3. "Beta titanium has to develop (only) 140,000 psi to be equivalent to 220,000 psi steel (which is almost near steel's top limits). But titanium's great potential above other alloys is reflected in the high figure for practical (based on elongation) yield strength. At 180,000 psi, beta titanium is equivalent to steel at 280,000 psi; at 200,000 psi, beta titanium is equivalent to steel at 320,000 psi. 200,000 psi in beta titanium is possible, and obviously would mean substantially increased payload to the moon or out into space.
4. "Apart from the strengths attainable in the beta titanium alloy, there is another property of considerable significance. Like other titanium alloys it has excellent resistance to corrosion under normal atmospheric conditions, in salt water as well as in many other media.

"In considering the long time storage problem with rocket cases — a pit in a thin-walled case can be catastrophic — we would regard the beta titanium alloy, as the outstanding material under consideration."

and in rocket case construction

PRATT & WHITNEY AIRCRAFT SURVEY OF ROCKET CASE MATERIALS

GENERAL PROGRAM

Goal: "A material capable of reaching 300,000 psi yield strength in steel, with a considerable development margin."

Result: "While this goal had to be modified for steel cases, we have successfully tested small scale titanium cases with a steel equivalent yield strength well beyond the 300,000 psi point."

Conclusions: 1. "By exercising reasonable care, the development of full scale (steel) cases at 240,000 psi is perfectly feasible."

2. "Small scale (titanium) cases have been burst at stress levels as high as 260,000 psi . . . we are convinced that reliable cases can be manufactured (from titanium) at yield strength levels of 180,000 psi and over . . . at 180,000 beta titanium is equivalent to steel at 280,000 psi."

"At 200,000 psi beta is equivalent to steel at 320,000 psi. 200,000 psi beta is possible and obviously would mean substantially increased payload to the moon or out into space."

SPECIFIC COMPARISON: Corrosion Resistance

Steel: "All of the low-alloy constructional steels which have been discussed are subject to general rusting and, far more serious, to pitting type corrosion during machining, welding, heat treatment, pressure testing and final storage. Corrosion pits can act as severe stress-raisers and, in conjunction with hydrogen, have been demonstrated to cause catastrophic failure. It therefore goes without saying that pitting corrosion is a serious hazard."

Titanium: "Like other titanium alloys, the beta titanium alloy has excellent resistance to corrosion under normal atmospheric conditions, in salt water as well as in many other media."

"In considering the long-time storage problems with rocket cases—a pit in a thin-walled casing can be catastrophic—we would regard the beta titanium alloy as the outstanding material under consideration."

SPECIFIC COMPARISON: Strength

Alloy	Density	Practical Yield Strength (5% elongation)
Ti-6Al-4V	0.161 \pm /in. ³	155 ksi = steel at 270 ksi
Ti-13V-11Cr-3Al (Beta)	0.175 \pm /in. ³	180 ksi = steel at 280 ksi 190 ksi = steel at 305 ksi 200 ksi = steel at 320 ksi

Burst Test Results show titanium has provided consistent burst strengths of 235,000 psi — a burst strength/density ratio of 1,340,000. Failure occurs in the wall of the case itself — not the weld zones. Titanium cases do not fragment.



Feasibility and growth . . . the parallel

Pratt & Whitney Aircraft data reveal that rocket-cases can now be built from beta titanium at strengths 17 percent greater than alternate metals, with beta titanium's strengths bounding forward under a minimum of development.

A striking parallel exists in liquid-fueled rocketry where titanium alloy Ti-6Al-4V was selected for helium storage bottles in the Atlas missile because of its strength/density ratio. Airrite Products, Inc., a leading supplier of the titanium vessels, reports:

"Minor modifications in processing techniques and continuous tightening of tolerances and other variables have won an increase from the original 100 psig average burst pressure to the present average which is in excess of 200 psig."

This has been done without increasing the weight of the article by one ounce. Weight of the unit, incidentally controlled to a tolerance of plus or minus one-half pound, on a weight of 79 pounds, and volume is controlled and guaranteed to plus or minus one percent."

"The performance of the titanium pressure vessels has been almost doubled, the price has been reduced by almost 50 percent — and the missile has become operational."

• When a case fails, so does the missile

The price of completed beta titanium rocket-cases is now estimated at 2½ times the price of other metals, with titanium cases virtually in their infancy. Should the titanium cost difference remain, the pay-off would still be two-fold:

- 1. Cost:** engineering time, would be greatly curtailed; expensive fuels (for example, 30 pounds of fuel are required in earlier stages for each additional third-stage pound) would be saved.
- 2. Reliability:** titanium cases simply will not pit, rust, deliquesce, or become hydrogen embrittled.

Added together, these elements mean feasibility—feasibility supported by the commercial availability of the metal itself. Beta titanium alloy Ti-13V-11Cr-3Al is available from Titanium Metals Corporation of America at these lead times: billet, 2-3 weeks; bar, 3-4 weeks; flat-roll, 5-6 weeks. TMCA's metallurgical experience with the alloy is yours for the asking.

For further information, write for **TMCA Data Bulletin 13, All-Beta Titanium for Solid Rocket Pressure Chambers**. Extensive welding information is included.



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RADAR ECHO . . .

The angular tracking precision of typical monopulse radars approaches one per cent of the antenna beamwidth. This practical limit of tracking accuracy is imposed by factors that are not related to the monopulse concept. For example, dynamic response of the antenna positioning servo, the antenna position data transducer, gear train backlash, boresighting procedures, and radome errors all produce errors over which "monopulse" has no control.

Simultaneous lobing doubtlessly will find many applications in areas other than automatic tracking. It is being used by radio astronomers to measure accurately the position of the stars and has also been applied to satellite tracking. Increased use will be made of systems in which the error signal serves as an electric analog of angle for range resolution.

By post-detection subtraction of the error from the sum signal, unwanted off-axis interference can be reduced. This feature can be used to provide a convenient means of warning against obstacles in the flight path of an aircraft.—End



Don't spoil it. KROIL it!

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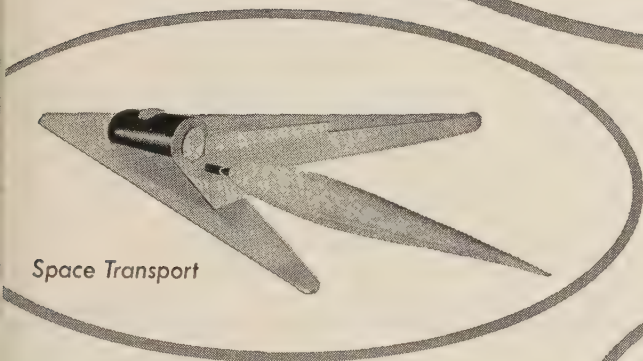
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SPACE/AERONAUTICS

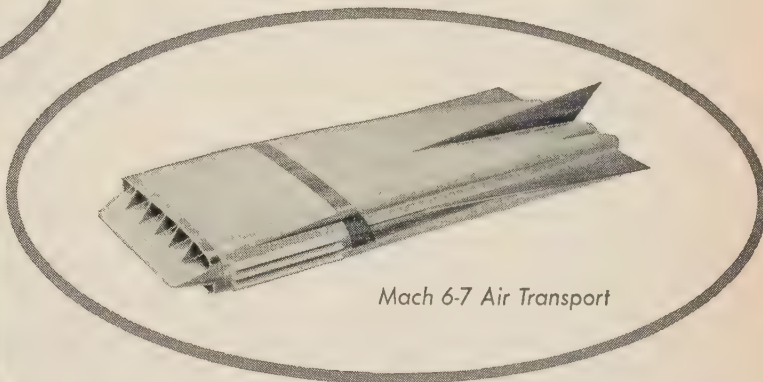


"Limocopter"



Space Transport

NEW FLIGHT FRONTIERS AND SPACE MISSIONS



Mach 6-7 Air Transport

Plans revealed in Lockheed's program of total flight technology

Space travel, whether the vehicle is manned or unmanned, poses vast problems. To expand the technology of flight, Lockheed's California Division proposes bold new concepts for both military and commercial vehicles. In line with this, the Company has assumed major responsibility for Research and Development on future space vehicles. This responsibility extends from development of advanced components to complete complex systems.

Advanced projects to spring from this broad base of Space travel include: Limousine-Helicopters designed for shuttle service between large cities and airports, or to transit terminals; Mach 6-7 Air Transport capable of take off and land vertically; Space transports capable of transporting, to an orbit of more than 1000 miles, a pilot and 1000 pounds of payload, three passengers equipped to work in space; advanced

Infrared Systems studies; and Solar Radiation studies.

This markedly expanded program into the total concept of flight creates urgent need for personnel with high-level skills. The concept ranges from subsonic to hypersonic speeds; from atmospheric to outer space vehicles.

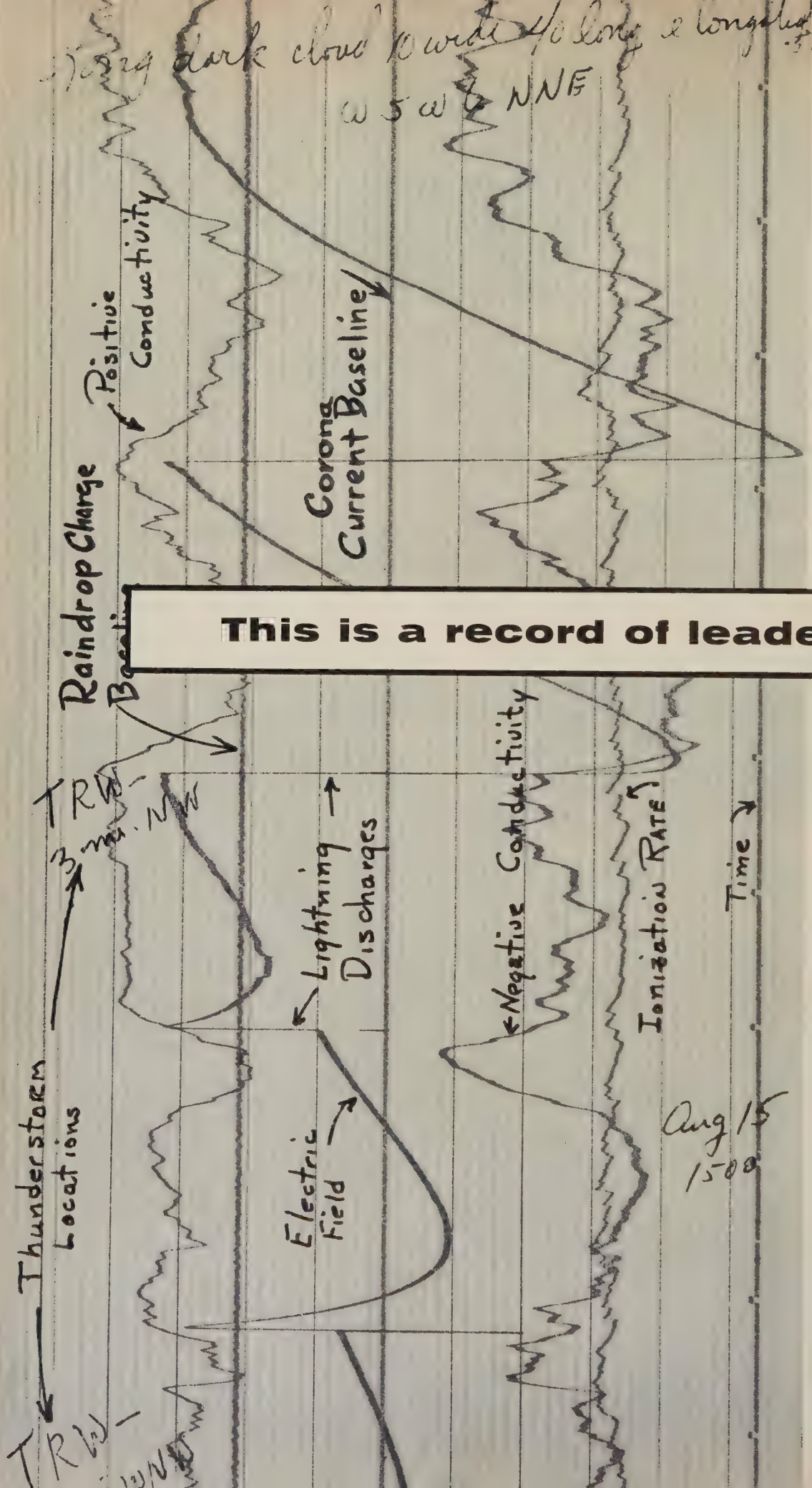
High-caliber scientists and engineers are invited to take advantage of this need; to investigate the many career opportunities Lockheed offers.

Immediate openings are available in: Aero-thermodynamics; propulsion; armament; electronics — research, systems, packaging; servomechanisms — flight controls; sound and vibration; physics—infrared, acoustics, electrophysical; antenna and telemetry; and underwater sound propagation.

Write today to: Mr. E. W. Des Lauriers, Manager Professional Placement Staff, Dept. 1901, 2400 North Hollywood Way, Burbank, California.

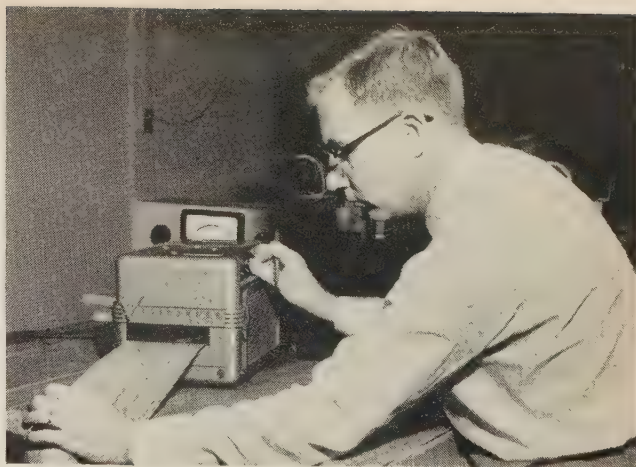
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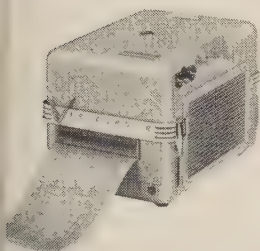
This is a record of leadership

The U.S. Weather Bureau used a Honeywell Model 906B Visicorder Oscillograph to record directly this diary of a thunderstorm as it passed near the observation station at Mt. Washburn in Yellowstone National Park. As the storm passed, the Visicorder measured and recorded 1) positive and negative electrical conductivity of the air, 2) the rate of ionization of air due to airborne radio-active particles and extra-terrestrial radiation, 3) the size and charge of individual raindrops, 4) the corona discharge current from an insulated tree and from a 4'x 6' grass plot to determine current flow from the earth's surface to charge centers in the clouds, 5) times of camera exposure photographing cloud droplet size and electrical charge, 6) atmosphere potential gradient, and 7) time. The Visicorder made this and many other records on Mt. Washburn without the use of power amplifiers. This feature, plus the extreme portability of the Visicorder, made it the ideal oscillograph for use in these studies.

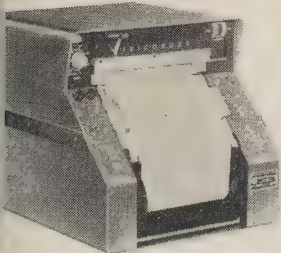


Byron Phillips, U. S. Weather Bureau Scientist, monitors thunderstorm data as it is recorded by the Honeywell Model 906 Visicorder.

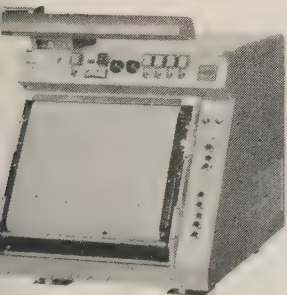
in weather research



Recent Models of the **906 Visicorder** incorporate time lines and grid lines and record up to 14 simultaneous channels of data.



The NEW Model **1108 Visicorder** with many automatic features and the convenience of push-button controls, is ideal for intermediate uses requiring up to 24 channels of data.



The Model **1012 Visicorder** is the most versatile and convenient oscillograph ever devised for recording as many as 36 channels of data.

The Honeywell Visicorder is the pioneer, completely proven, and unquestioned leader in the field of high-frequency, high-sensitivity, direct-recording ultra-violet oscillography. Here are some of the reasons why Visicorders provide the most accurate analog recordings available: constant flat response and sensitivity of galvanometers; grid-lines simultaneously recorded with traces to guarantee exact reference regardless of possible paper shift or shrinkage; flash-tube timing system for greater accuracy of time lines; superior optics for maximum linearity of traces.

No matter what field you are in . . . research, development, computing, rocketry, product design, control, nuclear electronics . . . the high-frequency (DC to 5000 cps) Visicorder Oscillograph will save you time and money in data acquisition.

Call your nearest Minneapolis-Honeywell Industrial Sales Office for a demonstration.

Reference Data: write for Bulletins 1108, 1012 and HC-906B
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FAIRCHILD TA-400 ACCELEROMETER SMALLEST EVER MADE

high shock and vibration resistance...

0.5% accuracy... self-torquing for system testing.*

This hermetically sealed linear accelerometer for missile and aircraft applications has an extremely sensitive differential transformer pick-off. It will measure accelerations from $\frac{1}{4}g$ to 50g. Viscous fluid damping is provided over a wide temperature range. *The pick-off is wired with additional taps to allow a DC or AC excitation (Filterable from pick-off excitation) to be superimposed. This torques the restrained pendulum in either direction from null.

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SHOCK: 100G EACH OF THREE AXES

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$\frac{7}{8}$ " Length
 $\frac{1}{16}$ " Diameter

General Characteristics

Range	$\pm \frac{1}{4}g$ to $\pm 50g$
Undamped natural frequency	10 175 cps
Output	Differential Transformer 6 volts into a 10K load. 400 cps phase sensitive
Null	15 to 50 MV
Accuracy	Including linearity, hysteresis, and repeatability after light tapping—0.5% of full scale to half scale.

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Solid Propellant and Exothermic Compositions, by James Taylor. Survey of chemical compositions which have been developed as sources of energy for various applications, based to a large extent on work done in Nobel Div. Laboratories of Imperial Chemical Laboratories of Britain. Interscience Publishers, Inc., 250 Fifth Ave., New York 1, N.Y. \$4.25.

Dictionary of Guided Missiles and Space Flight, edited by Grayson Merrill. Terms defined include current and historical guided missiles and spacecraft and their systems for guidance and control, launching, propulsion, armament, etc. System components also are covered. Related terms from various disciplines involved in missile-space technology are included. D. Van Nostrand Co., Princeton, N. J. \$17.50.

Helicopter Dynamics and Aerodynamics, by P. R. Payne. A comprehensive book on 'copter theory, this includes discussion of rotor blade flutter and cantilever, stiffhinged, high flapping pin offset and other advanced forms of rotor. The Macmillan Co., 60 Fifth Ave., New York 11, N.Y. \$17.

A Study of the Metallurgical Properties Necessary for Satisfactory Bearing Performance & Development of Improved Bearing Alloys for Service to 1000 Deg F, by T. V. Philip A. E. Nehrenberg, G. Steven. Part II of a study on high temperature bearing alloys conducted by Crucible Steel Co. for WADC, U. S. Dept. of Commerce, Office of Technical Services, Washington 25, D.C. \$1.75. (Report PB 151415.)

Combustion and Propulsion, Third AGARD Colloquium. Included in this volume are 18 papers presented at Palermo, Italy, in March 1958. Major areas covered include noise, shock, tube-magnetic effects and instability and mixing. Pergamon Press, 122 E. 55th St., New York 22, N.Y. \$20.

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SWITCHES • INDICATOR LIGHTS • SPECIAL ASSEMBLIES

ENGINEERING NEWS

Space-Saver Toggle Gives Big Switch Performance



When it comes to making a *real* saving in space, this new SP-DT Hetherington Toggle Switch is the answer. It is only $1\frac{1}{32}$ " in diameter by $1\frac{1}{32}$ " long. It

weighs less than $\frac{1}{4}$ oz. Yet it breaks down resistive loads at 28 volts dc $\frac{1}{2}$ amps @ 115 v ac for 50,000 operations.

Best of all, Hetherington's teatime-proof cam-roller snap-action gives the T3103 the "feel" of a real heavy-duty switch. Details are in Data Sheet S-3a.

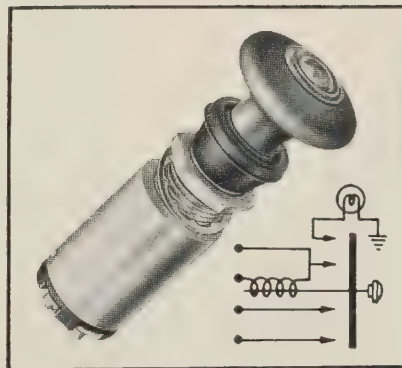
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Relay, Switch, and Pilot Light Functions in One Unit Only $\frac{15}{16}$ " x $3\frac{3}{8}$ "

is "control engineer's delight" as the work of *two* conventional switches plus a holding relay and indicator light. All of this is accomplished in only a fraction of the space, weight, and wiring needed for separate components.

Once the button is pressed, a built-in 28-volt solenoid holds the switch on contact until either the circuit is externally interrupted or the button is pulled out. A built-in indicator light shows when the coil circuit is energized.

Modifications of this basic Hetherington Holding Coil Switch design include a variety of circuit arrangements. Pull-on and push-on button types as well as a toggle type are available. Their many applications and industrial uses center



around jobs where the switch is manually "closed" to start an operation; then electrically "opened" at the end of the sequence. In an emergency, the switch may be manually opened in the middle of the sequence if desired.

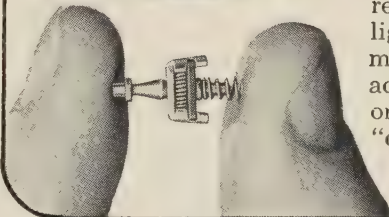
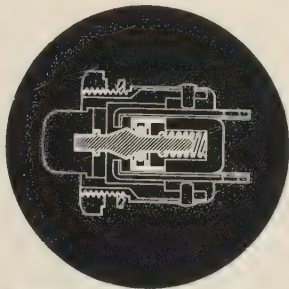
Write in No. 102 on Reader Service Card

HETHERINGTON INC. DELMAR DRIVE, FOLCROFT, PA. • 139 Illinois St., El Segundo, Calif.

The Switch Design That Says

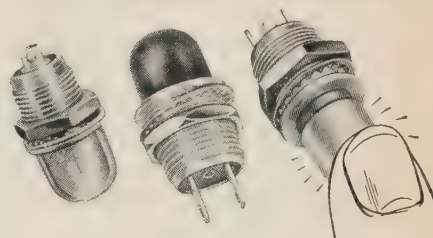
"NO FOOLIN"

No Tease . . . No Deceptive Clicks



Higher ratings in smaller, lighter-weight switches are made possible by this little beryllium device . . . the heart of every Hetherington snap-action switch.

A polished tapered rod operates through two compression springs in the shorting bar and against the return spring. Its lightning-fast, double-break snap action reduces arcing and contact welding to negligible proportions—even with high momentary overloads. Contact pressure is actually greatest at the point of "make" or "break" thus preventing deceptive "clicks" or contact teasing.



W-I-D-E Angle Visibility from Indicator Lights only $1\frac{1}{64}$ " Long

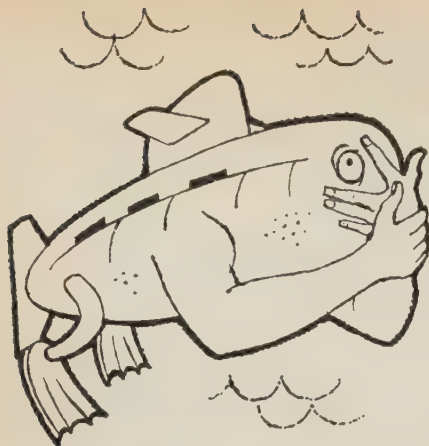
Almost 50 percent of the surface of these tiny units is useful illuminated area. Thanks to a specially-beveled lens cap, light is "piped" evenly throughout the entire lens. Full 180-degree visibility is assured on either standard or edge-lit panels.

These miniature Hetherington Series L6000 lights come in both 2-terminal ungrounded, or 1-terminal case-ground styles. Single piece terminals and contacts cannot be torn loose by heavy wires. Request Bulletin L-2b.

Write in No. 103 on Reader Service Card

Over 455 PRECISION push-button Switch Types

A Controls Company of America Subsidiary



UNDERSEA WARFARE

The "Silent Service" is hushing up

At present the "Silent Service" is really very noisy.

We know this and so does the enemy. That's why we're both working on truly silent underwater craft. "Classical" methods of detecting radiated noises are due for an overhaul, and Avion is prepared to commit its capability in depth to achieve this end.

In addition to our Long Range Submarine Detection Program, Study Projects are also underway involving:

- ASW Display Techniques
- Sonic Metering and Measuring Devices
- Sonobuoy Improvement
- Non-Sonic Detection
- Advanced Submarine Display Techniques

IF YOUR PROBLEM IS UNDERSEA WARFARE INSTRUMENTATION, WE CAN HELP YOU...CALL US.

Top assignments open in this field

AVION

FOREMOST IN AVIONICS

AVION DIVISION

QCF INDUSTRIES INCORPORATED

11 PARK PLACE, PARAMUS 1, N. J.

Write in No. 116 on Reader Service Card

electronics scanner

AIR FORCE'S R&D needs will now be made known directly to science and industry through the release by ARDC of its Applied Research Planning Documents (ARPDs, formerly "Technical Program Planning Documents"). These documents are in effect "technical work orders" that define and describe USAF's technical problems that must be solved before systems planned for the future can become operational.

Among the ARPDs now available from ARDC, these will be most important to electronic groups: Materials (720H), Navigation and Guidance (730D), Flight Control (730E), Weapon Fire Control (730F), Computer and Data Processing Techniques (730J), Surveillance Techniques (760B), Communications (760C), Electromagnetic Warfare (760D), Electronic Techniques (760E), Reconnaissance (760F), Electromagnetic Vulnerability Reduction (760G), Intelligence Techniques (760H), Electromagnetic Wave Techniques (760K), Aerospace Environment (770A).

TO RECEIVE ARPDs, an organization must be an R&D contractor or have the capability to be one. It also must have proper security clearances. (Most ARPDs are secret.) Interested organizations should get in touch with Hq, Air Research & Development command, Andrews AFB, Washington 25, D. C.

SUPPLEMENTS to BuShips' Reliability Design Handbook will again be published quarterly. (Publication was suspended last January.)

The latest supplement, now available, from Office of Technical Services, Washington 25, D. C., is dated Oct. 15. The name of the basic book has been changed from "NEL Reliability Design Handbook" to "Navy Reliability Design Handbook."

LACK of technical understanding is one of the main gripes many industrial R&D groups have against the military customer. Industry, it seems, has skimmed off too many of the most competent engineers from Army, Navy, and USAF

R&D centers. One of the most frustrating experiences that can befall a technical group in the industry is to see its ideas or products judged by incompetent appraisers. These naturally evaluate on some basis that they understand—and often, unfortunately, the proper basis of evaluation is beyond their technical scope.

A BASIC mistake in R&D contracting, claims section head for a leading inertial-guidance manufacturer, is to award contracts for the same project to more than one contractor. The reason for such duplication, according to the section head, lies in the inability of military evaluation groups to select the technically best proposal when several proposals have been submitted to them. By selecting more than one proposal, not only does the military put off its decision to a stage at which it is far more difficult to make a proper analysis of the pros and cons of each approach, but they also spread the R&D money too thin.

GYROS are one of newest applications of cryogenics. Jet Propulsion Lab is experimenting with a gyro made up of a superconducting sphere supported by a magnetic field. Liquid-helium temperatures are used. JPL expects to get exceptionally low drift rates.

BULOVA RESEARCH LABS is one of several groups studying the use of infrared to detect submerged submarines. Details are super-secret.

SOME 400 COMPANIES have shown interest in the Office of Naval Research's "submarine integrated control" (Subic) program. Some 240 of these companies are in the aerospace industry, according to Electric Boat, manager of the Subic program. Right now Electric Boat and its subcontractors are trying to work out the equations of motion of submarines and their targets.

BELIEVE IT OR NOT: The British once tried to train seals to tell underwater mines from other submerged objects. And the Swedes tried to train seals to detect subs.

Write in No. 143 on Reader Service Card →
SPACE/AERONAUTICS



WON'T SMEAR ON MYLAR!®

Duralar

Still the only pencil

that **can't smear** on Mylar,
that **keeps a point** on Mylar,
that **erases** on Mylar.

Duralar drawings on Mylar
reproduce perfectly, **microfilm**
without loss and can even
be **cleaned** with soap and water.

For free samples

of Duralar pencil and leads and
leading brands of matte-surface
Mylar drafting film, just fill out
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business letterhead.

See for yourself how the
sensational new Mars Duralar
solves your drafting problems.

And Duralar is available
(pencils, leads and lead holders)
in five special new
grades of hardness (K1 to K5).
and at leading engineering and
drawing material suppliers.

W! No. 555 Duralar Eraser



Another first from

MARS

J. S. STAEDTLER, INC. HACKENSACK, N. J.

Gentlemen: Please send me FREE

☐ Samples of revolutionary DURALAR pencil and leads

☐ Samples of Mylar film for testing DURALAR

☐ A copy of the booklet "The Advantages of Using
Mylar Drafting Film"

NAME _____ TITLE _____

FIRM _____

STREET _____

CITY _____ ZONE _____ STATE _____



professional opportunities in ASW at Honeywell Ordnance

Working in three locations—Minneapolis, Duarte*, Seattle—Honeywell Ordnance is engaged in the following areas of anti-submarine warfare: search, detection, localization, classification, kill and assessment. Current responsibilities are for overall system analysis, design and development of missile systems, components, support equipment and trainers.

Among current U. S. Navy projects in which Honeywell is participating are: prime contract with system responsibility on ASROC anti-submarine missile . . . a shore-based ASW weapons system team trainer . . . a sonic sea range system for plotting the hydroballistic trajectory of underwater weapons . . . a sonic transponder system for tracking the path of high speed torpedoes and subs . . . a sonar training device for teaching proper action and response to sonar signals . . . complex fuzing and arming devices for missiles, mines, etc . . . an integrated PPI display capable of simultaneously superimposing radar, sonar, and fire control information aboard ship.

Presently, Honeywell's Ordnance Division has openings at all levels for systems analysts and research, development, and design en-

gineers. A few of the specific openings are as follows:

SYSTEMS ANALYST: Degree in physics or math with 5 years' experience—some background in anti-submarine warfare.

ELECTRONIC DESIGNER: EE with minimum of 2 years' experience on small mechanical or electro-mechanical devices.

SONAR AND OTHER UNDERWATER ACOUSTIC SYSTEMS ENGINEERS: Experience with transducer design, systems concept, signal processing and data correlation techniques desirable.

TEST AND CHECKOUT EQUIPMENT ENGINEERS: Experience with instrumentation, automatic inspection equipment and military checkout equipment desirable—for work on complex missile systems and multiple component test and checkout equipment.

**Near Pasadena, California*

If you're a qualified engineer interested in opportunities with Honeywell Ordnance, please write in confidence to F. W. Miller, Dept. 213.

To explore professional opportunities in other Honeywell operations coast to coast, send your application in confidence to H. D. Eckstrom, Honeywell, Minneapolis 8, Minnesota.

Honeywell 
ORDNANCE DIVISION
2753 Fourth Avenue South, Minneapolis 8, Minn.

January 1960
(good until 3/15/60)

Employment Inquiry Form

(Not an application for employment)

THIS INQUIRY FORM is a service that makes it easier for the interested reader to explore employment opportunities with organizations featuring recruitments advertising in this issue.

To use this Form, follow these simple steps:

- (1) Tear out this page.
- (2) Check off the organization(s) listed below whose employment offers are of interest to you. Use **typewriter or pencil**.
- (3) Turn to the back page of this Form and answer the questions on it.
- (4) Mail this form (in a stamped envelope) to:

Reader-Service Dept.

SPACE/AERONAUTICS

205 East 42nd St.

New York 17, N.Y.

We will do the rest and promptly forward a copy of your Inquiry Form to each of the organizations you have checked. Depending on their specific personnel requirements, they will get in touch with you at your home.

I am interested in the employment opportunities at:

<input type="checkbox"/> AC—The Electronics Div. of GMC	173	<input type="checkbox"/> Missiles & Space Div.	170, 171
<input type="checkbox"/> Aeronutronic Systems, Inc.; A Subsid. of Ford Motor Co.	202	<input type="checkbox"/> Magnavox Procurement Div.	195
<input type="checkbox"/> AiResearch Mfg. Co.	178	<input type="checkbox"/> Martin Co.; Denver Div.	174
<input type="checkbox"/> Avco Mfg. Corp.	87, 245	<input type="checkbox"/> Minneapolis-Honeywell Regulator Co.	
<input type="checkbox"/> Bendix-Pacific	204, 247	<input type="checkbox"/> Aero Div.	201
<input type="checkbox"/> Chance-Vought Aircraft	198	<input type="checkbox"/> Ordnance Div.	204
<input type="checkbox"/> Convair; Astronautics Engrg. Div.	94, 262	<input type="checkbox"/> Seattle Development Labs.	192
<input type="checkbox"/> Cornell Aeronautical Lab., Inc.	36	<input type="checkbox"/> Pan American Airways, Inc.;	
<input type="checkbox"/> Douglas Aircraft Corp.	78, 79	<input type="checkbox"/> Guided Missiles Range Div.	293
<input type="checkbox"/> Garrett Corp.	178	<input type="checkbox"/> RCA	196, 202
<input type="checkbox"/> General Electric Co.		<input type="checkbox"/> Republic Aviation Corp.	207
<input type="checkbox"/> Light Military Electronics Dept.	205	<input type="checkbox"/> Rohr Aircraft Corp.	206
<input type="checkbox"/> MSVD	197	<input type="checkbox"/> Solar Aircraft Corp.	200
<input type="checkbox"/> General Motors Corp.;		<input type="checkbox"/> Space Tech Labs.	27
<input type="checkbox"/> AC—The Electronics Div.	173	<input type="checkbox"/> Stavid Engrg.	208
<input type="checkbox"/> Guided Missiles Range Div.;		<input type="checkbox"/> Systems Development Corp.	199
<input type="checkbox"/> PanAm Airways, Inc.	293	<input type="checkbox"/> Vitro Weapons Services	198
<input type="checkbox"/> Lockheed Aircraft Corp.		<input type="checkbox"/> Westinghouse Electric Corp.	203
<input type="checkbox"/> Calif. Div.	185		

OTHER (Some organizations' recruitment advertising in this issue may have arrived too late for inclusion in the above list. If you are interested in the employment offers of any of these organizations, just note its name and the page number of its advertisement in this space. Please refer only to ads keyed to this form.): _____

NOTE: If you have an immediate interest in any special employment opportunity advertised in this issue and would like to give more details about your qualifications than can be noted on this Form, we advise you to send your resume directly to the person or department given in the advertisement. We'd appreciate it if you'd mention SPACE/AERONAUTICS in your application.

January 1960
(good until 3/15/60)

Employment Inquiry Form

Please type or print (with pencil)

(NOT an application for employment)

FIELDS OF INTEREST (in order of importance, note the general fields in which you would like to work—e.g., basic research, dynamics, structures, rocket propulsion, electronic systems, pneumatics, testing, materials, production, ground support, etc.): _____

SPECIALIZED JOB EXPERIENCE (describe the specific technical areas in which you have worked—e.g., flutter, fatigue, fuel systems, circuit miniaturization, servo systems, hydraulic pumps, tool engineering, orbit mechanics, telemetry, data processing, wind tunnel testing, etc.): _____

JOBS AND EDUCATION

List your last 3 employers:

EMPLOYER	CITY & STATE	YEARS EMPLOYED	JOB TITLE OR FUNCTION

List your college and university degrees:

SCHOOL	YEARS ATTENDED	DEGREE

Special Training _____

PERSONAL DATA

AGE U. S. CITIZEN ☐ YES ☐ NO If not, when do you expect to become a citizen?

Name:

Home Address:

Home Telephone:

Make sure you have checked the companies you are interested in on the other side of this Form. Then put the Form in a stamped envelope and mail it to Space/Aeronautics.

not just another pebble . . .



at magnavox there's no getting lost in the crowd. As an engineer in our government and industrial divisions, you stand out as an individual with ideas. Ideas that we listen to. Ideas that are put into motion. Ideas that step you ahead . . . fast.

But while we gladly admit to NOT being a giant, neither do we take a back seat to anyone in the kind of creative climate we offer engineers. We are, in fact, currently engaged in a vast number of highly specialized areas of electronic activity and our customers rank among the principal names in business and government both here and abroad.

At present, we need engineers to carry on expanding programs in communications, airborne radar, missiles, anti-submarine warfare systems and data processing equipment. The projects we have on tap are broad and challenging. The men we offer as your associates are high caliber creative scientists like yourself. And the technical facilities we provide are the finest, most complete anywhere.



FORT WAYNE, INDIANA



URBANA, ILLINOIS



LOS ANGELES, CALIFORNIA

If you're a man who likes to accept challenge—and wants to be recognized for it—we'd be glad to hear from you. Phone Dick Eary (collect, of course) at Eastbrook 9721 in Fort Wayne or write him today for complete information.

Magnavox



COMMUNICATIONS



RADAR



DATA HANDLING



ASW



MISSILES

THE MAGNAVOX CO. • DEPT. 231 • Government and Industrial Division • FORT WAYNE, IND.

Check Employment Inquiry Form on Page 193

A SPECIAL KIND OF POSITION FOR SPECIAL KIND OF MEN

To help meet the urgent and continuing problems of national security, RCA has created an Advanced Military Systems Department at Princeton, New Jersey. There, in an atmosphere of complete intellectual freedom, men of a very special kind are engaged in highly sophisticated analysis and study of our national defenses—present and future—and how they can be made most effective to meet any future enemy capability.

THE POSITION—Studies conducted by the RCA Advanced Military Systems Department are of the broadest scope and cover such diverse areas as physical and engineering sciences, military science, economics and geophysics. Accordingly, each member of the technical staff may select his own area of work. The only requirement: results must have a direct application to problems of national defense.

Each staff member is provided with every opportunity, facility and detail of environment to use his creative and analytical skills to maximum advantage and at the highest level. He has no responsibility for administrative details. He can call in any specialists he may need. He has full access to all available information—military, academic and industrial. Furthermore, specialized research projects and laboratory work can be carried out at his request by other departments of RCA.

THE MEN—The men who form the technical staff are a group of mature scientists and engineers. They are accustomed to responsible positions in industrial research, advanced development, or systems planning. Most of them have an extensive background in the broad fields of electronics, vehicle dynamics (space, marine or terrestrial), physics (astro, nuclear, or plasma), or operations research (military science). All are men who enjoy seeing the fruits of their work have a far-reaching effect on the defenses of the country.

THE LOCATION—Princeton offers unique civic, cultural and educational advantages. The RCA Advanced Military Systems Department itself occupies a new, air-conditioned building on the quiet, spacious grounds of RCA's David Sarnoff Research Center.

INQUIRIES ARE INVITED—If you are interested in learning more about this far-reaching program and the unusual opportunities it offers to qualified men, write:

Dr. N. I. Korman, Director
Advanced Military Systems, Dept. AM-7A
RADIO CORPORATION OF AMERICA
Princeton, New Jersey



**RADIO CORPORATION
of AMERICA**

ATTENTION EMPLOYMENT MANAGERS

This new "Employment Opportunities" section allows you greater choice in positioning advertisements—in keeping with your recruitment objectives.

If the purpose of your campaign is to alert readers to immediate job openings you'll find the new section ideal for this need.

If, on the other hand, your aim is to acquaint readers with your organization—the scope of its operation, new projects getting underway, extra benefits, etc.—you may find any other part of the magazine more suitable for this purpose.

But no matter where you position your employment advertising, your company will be listed on the "Employment Inquiry" form which appears in this section.

Although not an application for employment, it provides you with detailed information about technical personnel interested in your company. After evaluating their specialized job interests, experience and formal education—which must be included in the form before it is sent to you—you can personally contact those best qualified for the job.

When scheduling your recruitment advertisements in Space/Aeronautics, be sure the insertion order specifies where you want the advertisement to appear—"run-of-book" or in the "Employment Opportunities" section.

General Electric's Missile & Space Vehicle Dept. Building New \$14,000,000 Space Research Center

17 miles from Philadelphia, Near Valley Forge Park

Back in 1956 this General Electric organization outgrew its quarters in Schenectady, N. Y. and moved to Philadelphia. Since then its research and development staff has increased 5-fold. A new move is fast becoming imperative and will be met by the \$14,000,000 Space Research Center now under construction on a 132 acres site near Valley Forge Park. This construction will feature unique facilities, to be utilized in a long-term program, to expand the activities in the realm of space research and the development of space vehicles and systems—areas in which MSVD has already contributed so many notable advances:

- the FIRST re-entry at ICBM range with both heatsink and ablation methods
- the FIRST recovery of payload from space
- the FIRST movies of earth from space
- the FIRST flight demonstration of effective space vehicle stabilization control and navigation (control systems of interplanetary capacity)
- the FIRST measurements in space of earth's magnetic field and infrared radiation
- the FIRST meteorological information from space
- the FIRST organic plastic ablation material for nose cone re-entry protection capable of withstanding temperatures from 5,000 to 13,000°F

Currently a broad diversity of programs are under way at MSVD, offering assignments of exceptional interest to engineers and scientists qualified to work with a research-oriented organization. Your inquiries are invited regarding the following areas: SYSTEMS ENGINEERING • AERODYNAMICS • THERMODYNAMICS • GUIDANCE & CONTROL • INSTRUMENTATION & COMMUNICATION • PLASMA PHYSICS • GAS DYNAMICS • AEROMEDICAL DESIGN ENGINEERING • ANTENNA & MICROWAVE DESIGN • SPACE MECHANICS • STRUCTURAL DESIGN • ENERGY CONVERSION • HUMAN FACTORS • ADVANCED POWER SYSTEMS • RELIABILITY ENGINEERING • PRODUCIBILITY ENGINEERING • ARMING AND FUZZING SYSTEMS • APPLIED MATHEMATICS & COMPUTER PROGRAMMING

Write in confidence to: Mr. Thomas H. Sebring, Div. 60-MA
Missile & Space Vehicle Department

GENERAL  ELECTRIC

3198 Chestnut St., Philadelphia 4, Pa.

DIVERSITY OF ADVANCED PROGRAMS NOW UNDER WAY AT MSVD INCLUDE:

- Follow-on contracts for 2nd generation nose cones
- NERV (Nuclear Emulsion Recovery Vehicles) for NASA to study the lower Van Allen radiation belts at altitudes from 200 to 1800 miles
- STEER—a communications satellite to provide global military radio communications.
- Study programs in the area of accessory space power for a variety of missions, including chemical, nuclear and solar energy sources, electrolytic fuel cells and thermoelectric and thermionic converters
- Studies for three of the nation's space agencies to develop more accurate "space maps" than have hitherto existed to guide rockets and manned flights to the moon and planets

A well qualified scientist or engineer is likely to find advanced work going on at MSVD on almost any field of space research of special interest to him.

A campus-like setting is planned for the new Space Research Center which General Electric's Missile and Space Vehicle Department is building close to historic Valley Forge Park. Situated at the junction of the Schuylkill Expressway and Pennsylvania Turnpike, the Center will be easily reached by engineers and scientists living in the Philadelphia area and in southern New Jersey.



How, today, does a man advance most rapidly?

Your present ability and potential in a space-age specialty are important to Chance Vought. And you know from experience that advancement comes quickest when ability can be used immediately, *demonstrated* to the fullest.

Five divisions at Chance Vought now make it easier for the professional man to pinpoint the area that will make the fullest demands on his talents... and that will advance him accordingly. Vought's five divisions also provide a balanced backlog that means diversification, plus the fresh challenge of working with new knowledge.

AERONAUTICS

AERONAUTICS DIVISION

Developing new generations of manned aircraft, atmospheric missiles, antisubmarine apparatus. Current work includes Navy-sponsored studies in submarine detection and classification; production of three versions of F8U *Crusader* aircraft.

ASTRONAUTICS

ASTRONAUTICS DIVISION

Concentrating on advanced vehicles for space exploration and on ballistic and anti-ballistic missile systems. Supplying four-stage *Scout* research rockets and launchers to NASA. Participation in the competition for the development of the *Dyna-Soar* boost-glide vehicle.

ELECTRONICS

ELECTRONICS DIVISION

Developing, manufacturing, marketing military systems including antennas and related electronics, ground support electronics, and antisubmarine apparatus.

RANGE SYSTEMS

RANGE SYSTEMS DIVISION

Establishing and operating test ranges and test equipment for missiles and space vehicles. Twelve years' experience in remote base operation.

RESEARCH

RESEARCH DIVISION

Looking forward to a new Research Center. Basic research into astronautics, undersea warfare, the life sciences (relating to the human factors of flight), electrogravities and other areas.

One Vought division may well stand out *today* as a place for your most rapid advancement. Why not write for further information?

Professional Placement Office
Dept. O-13

CHANCE
VOUGHT
DALLAS, TEXAS

You live at a discount in Dallas. In Texas there are no state income tax and no local or state sales taxes. Low school and property levies add to your savings. Home construction costs — as well as house and apartment rentals — are below the national average. Fuel costs are negligible, and most groceries cost less.

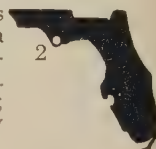
Check Employment Inquiry Form on Page 193

new openings in Florida with Vitro

Vitro Laboratories' Florida operation, Vitro Weapons Services, is rapidly expanding its technical staff to operate the nation's newest missile test range, the EGLIN GULF TEST RANGE.



High level supervisory and staff opportunities exist at five Florida locations: 1. Fort Walton Beach; 2. Port St. Joe; 3. Tarpon Springs; 4. Naples and 5. Key West.



ELECTRONIC ENGINEERS — with degree(s) and several years experience in Automatic Tracking Radar, Electronic Instrumentation, Phase Comparison Space Positioning Systems, Data Recording and Conversion, Telemetry or Missile Range Instrumentation.



RADAR TECHNICIANS — with training and experience in one or more of the following radar systems: MSQ-1, MSQ-1A, FPS-16, Nike, M-33, MPS-9, SCR-584, CPS-6, FPS-3 and FPS-20.



ELECTRONIC TECHNICIANS — with a solid background in electronics and several years experience in Telemetry, Data Converters, Oscillograph Recorders or Range Electronic Instrumentation.

For your opportunity to relocate in Florida with an electronics industry leader, address a confidential resume to D. D. Cox, Personnel Director, Vitro Weapons Services, 119 East Main Street, Fort Walton Beach, Florida, Dept. SA.

Vitro
LABORATORIES

DIVISION OF VITRO CORPORATION OF AMERICA
Other laboratories at West Orange, N. J.,
and Silver Spring, Md.

Check Employment Inquiry Form on Page 193
SPACE/AERONAUTICS



A nalytical Engineers:

*Are your skills being used
in truly advanced work?*

Are you satisfied with the way your native abilities, training and experience are being utilized? Is the scope broad enough for you? Must you constantly tread the same territory, or can you plunge into the woods to pit your skills against new challenges?

If you are not interested in exploring new technological terrain, you will not be interested in System Development Corporation. For our work is concerned with the development of extremely large control systems in which the relationships of men and machines pose entirely new problems for analytical engineers.

At the present time we have key openings for engineers with proved analytical ability in the areas of communications, computers and associated equipment, simulation, information theory, weapons system analysis. Please send your inquiry to Mr. E. A. Shaw, SDC, 2424 Colorado Avenue, Santa Monica, California.

.....
"A Mathematical Model of an Air Defense Operation and a Method of Evaluation," a paper by SDC's staff, is available upon request. Please address inquiries to Mr. E. A. Shaw at SDC.
.....



**SYSTEM DEVELOPMENT
CORPORATION**

Santa Monica, California • Lodi, New Jersey

Check Employment Inquiry Form on Page 193

Openings for

DESIGN ENGINEERS

for

GAS TURBINE ENGINES

in Solar's rapidly expanding
gas turbine programs
in sunny San Diego

Solar has immediate openings for Preliminary Design and Product Design Engineers in its fast-moving gas turbine programs. Several new contracts have been received for industrial, non-military applications, as well as certain new military turbine development jobs. This growing diversification has created expanding challenges and opportunities. Solar is a world leader in small gas turbines, having pioneered in their design and development since 1945. The company has built and sold more than 2500 gas turbines. Join in this exciting work now for a brilliant future.

QUALIFICATIONS

B.S. in Engineering preferred, plus at least three years experience in gas turbine design. U.S. citizenship not required for some of the positions open.

SOLAR SPECIFICS

Solar is a medium-sized company (2500 people) that has been in the mechanical and aeronautical engineering fields since 1927. It is big enough to offer the most advanced personnel policies, yet small enough so you don't get lost in the crowd. Salary and performance reviewed semi-annually. Liberal relocation allowances. The special professional status of engineers is appreciated and recognized. A new 60,000 sq. ft. engineering building, necessitated by expanding research and development, will be completed soon on the edge of San Diego Bay.

SEND RESUME

Please send resume of your qualifications to Louis Klein, Dept. E-451, Solar Aircraft Company, 2200 Pacific Highway, San Diego 12, California.

SOLAR
AIRCRAFT COMPANY



LIVE BETTER, TOO! In addition to greater opportunities for personal achievement, Solar offers you the chance to live better in sunny San Diego. This famous resort area has the finest year-around climate in America. Cultural, recreational and educational facilities are excellent. You and your family will enjoy life more at Solar in San Diego.

IMPORTANT

In filling out "Employment Inquiry Form" be sure to print clearly. When you check more than one company, the form must be photostated so that each company receives a copy.

PROPER PROCESSING
DEMANDS LEGIBILITY



professional opportunities at Honeywell Aero

INERTIAL SYSTEM DEVELOPMENT

Systems Analyst—employs mathematical techniques such as operational calculus, matrix algebra, and difference equations to the solution of problems concerning performance characteristics of various system configurations including analysis for error introduced by sensors and computer, requirements for alignment, and optimization of the system configuration.

Digital System and Logic Designer—requires familiarity with capabilities of various digital computer configurations and ability to employ system and logic relations in specifying necessary configuration for solving inertial navigation problem.

Electronic and Mechanical Designers—engineers with background in transistor circuitry, inertial sensor development and evaluation, and precision mechanical equipment design are needed to perform component development and evaluation, and to design mounting and alignment equipment.

APPLIED RESEARCH

Programmer Analyst—mathematician with experience in the use of medium and large scale digital computers for analysis of scientific problems.

Human Factors Engineer—capable of analysis and direction of experiments in human motor skills, and application to man-machine sys-

tems involving automatic control techniques.

Systems Analyst—capable of conducting research studies involving new techniques of space navigation and guidance.

DESIGN AND DEVELOPMENT

Flight Control Systems—analytical, systems, and component engineers to work in areas such as advanced flight reference and guidance systems. Positions range from analyzing stability and control problems, systems engineering—through design, testing, and proof of electrical and mechanical equipment—including flight test and production test.

Advanced Gyro Design—Engineers with two and up to twenty years' experience in precision gyro and accelerometer development, servo techniques, digital techniques, solid state electronic development, advanced instrumentation and magnetic component design.

Electronic Circuit Designers—experienced in the areas of analog/digital computers, transistor circuits, servos, instrumentation, and/or gyro stabilization.

For the less experienced professional engineer, there are opportunities in the Evaluation Laboratory which lead to careers in any of the above fields.

To investigate any of the above professional opportunities at the Aeronautical Division, please write in confidence to Bruce Wood, Dept. 275

To explore professional opportunities in other Honeywell operations coast to coast, send your application to H. K. Eckstrom, Honeywell, Minneapolis 8, Minnesota.

Honeywell



AERONAUTICAL DIVISION
1433 Stinson Blvd. NE, Minneapolis 13, Minnesota

Check Employment Inquiry Form on Page 193

Systems Engineers . . .

Solve the Puzzles of

UNDERSEA WARFARE

...WITH RCA!

RCA's Airborne Systems Division, a long-time leader in the development of airborne electronic systems and equipment, is now engaged in devising undersea warfare systems . . . to provide one of the most vital links in the chain of our defense. These systems necessitate the solving of challenging problems in the areas of general operations, sound propagation and signal recovery, and fire control.

As an RCA systems engineer, you will not only be responsible for creating some of today's most strategic defense weaponry . . . but will be able to advance rapidly, *as an individual*, on a highly liberal merit basis. Because of the far-reaching and important nature of your assignment, opportunities for professional growth are virtually unlimited. To keep you free for only *creative* activities, a vast array of well-staffed, well-equipped facilities—both research and manufacturing—are on hand to support you at all times.

A select number of openings now exist for systems engineers and operations analysis personnel with experience in sea or undersea warfare systems. If you qualify, you may secure further information by sending a résumé to:

Mr. C. B. Gordon, Dept. Z-16A
Professional Placement Office
RCA, Bldg. 10-1
Camden 2, New Jersey



RADIO CORPORATION of AMERICA
DEFENSE ELECTRONIC PRODUCTS

RESEARCH OPPORTUNITIES
in

SPACE SCIENCES

The Space Technology Operations of Aeronutronic has immediate need for engineers and scientists who are interested in working in the stimulating and highly diversified field of space sciences. This West Coast division of Ford Motor Company has the newest facilities and most advanced equipment for carrying out highly technical work — challenging creative work that is exceptionally rewarding to qualified men.

Positions are at Aeronutronic's new \$22 million Research Center, being completed at Newport Beach, Southern California. Here, overlooking famous Newport Harbor and the Pacific Ocean, relaxed California living can be enjoyed free of big-city congestion, yet most of the important cultural and educational centers are just a short drive away.

AREAS OF INTEREST

VEHICLE TECHNOLOGY

Aerodynamic design and testing
Rocket Nozzle and re-entry materials
High temperature chemical kinetics
Combustion thermodynamics
High temperature structural plastics and ceramics
Advanced structures

SYSTEMS DEVELOPMENT

Aerothermodynamics
Re-entry programs
High temperature heat transfer
Penetration systems
Hyper environmental test systems

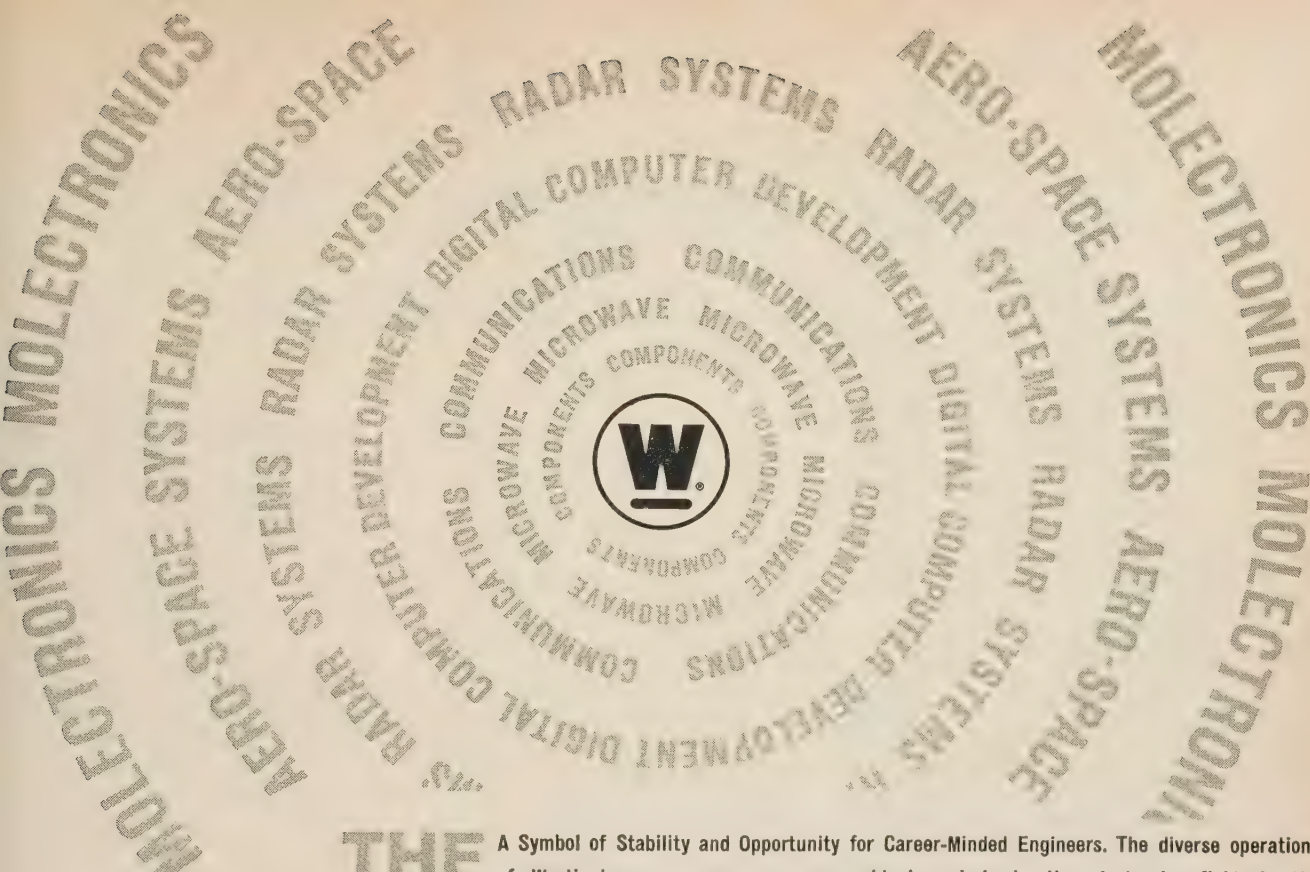
ELECTRONICS AND ASTRO SCIENCES

Astro navigation
Space communications and communication satellites
Instrumentation, telemetering and data reduction
Space environmental physics
Advanced techniques and system studies

Qualified applicants are invited to send resumes and inquiries to Mr. G. B. Eaton, Aeronutronic, Dept. 11, Box 451, Newport Beach, California.

AERONUTRONIC

a Division of Ford Motor Company
Newport Beach
Santa Ana • Maywood, California



THE WIDENING CIRCLE

A Symbol of Stability and Opportunity for Career-Minded Engineers. The diverse operations of Westinghouse encompass an ever-widening circle in the electronics field. In the Baltimore Divisions, Westinghouse engineers are further widening these horizons, with advanced projects in airborne, shipboard and land-based electronic systems. Here we are engaged in challenging research, development, production and field engineering assignments covering the electronic spectrum.

Westinghouse diversity offers new avenues for your own career growth. If you want to go farther, faster . . . join the select circle of engineers at the Baltimore Divisions of Westinghouse.

OPPORTUNITIES EXIST IN:

Radar Systems

Molecular Electronics

Advanced Antenna and Microwave Systems

Digital Computer Development

Automatic Checkout & Fault Isolation

Liaison Engineering

Communications Systems

Astronautics Systems

SEND YOUR RESUME TO: Mr. A. M. Johnston, Dept. 219

Westinghouse

BALTIMORE

P. O. Box 746

Baltimore 3, Maryland

AIR ARM • ELECTRONICS • ORDNANCE

Check Employment Inquiry Form on Page 193



*systems
analyst*

B.S. and preferably M.S. in physics, math, M.E., or E.E. Should have a sound background in physics and mathematics, with experience in the field of anti-submarine warfare or underwater ordnance. Industrial or government research laboratory experience in ASW would be particularly desirable.

Please write F. W. Miller, Dept. 214, Honeywell, 2753 Fourth Avenue South, Minneapolis.

Honeywell
First in Controls

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Investigating Employment Opportunities?

Want more information about employment opportunities offered by companies advertising in this issue? Then be sure to give complete data about your job interests, experience and education when filling in the "Employment Inquiry" form.

Although not an application for employment, it provides employment managers with information to evaluate your capabilities—and in turn gives your request immediate consideration.

Check the "Employment Inquiry" form for details.

BENDIX-PACIFIC NEEDS SYSTEMS
AND CIRCUIT DESIGNERS FOR

advanced
submarine
detection
systems

Unusual Creative Opportunities for

- Electronic engineers with a well rounded background to participate in a unique research and development program.
- Qualified mechanical design engineers including structural thermo-dynamicists in this challenging new field.

SEND RESUME OF YOUR QUALIFICATIONS TO MR. WALKER AT



Check Employment Inquiry Form on Page 193

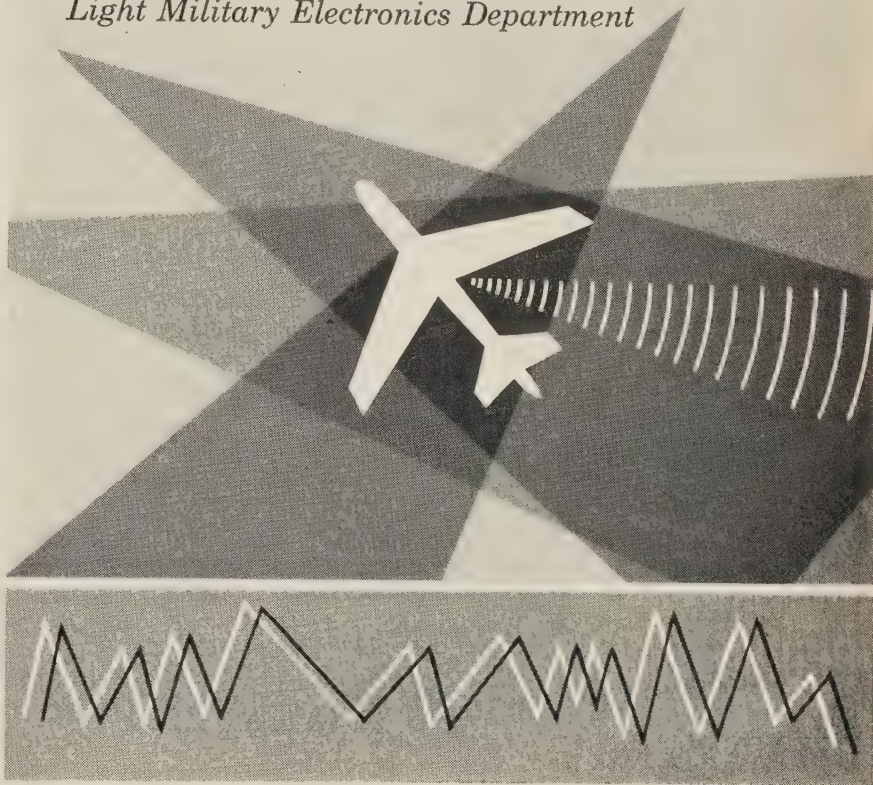
ATTENTION ALL ENGINEERS

you are seeking new
opportunities be sure
read all employment
advertisements in this
Special Section and
throughout the magazine

ELECTRONIC ENGINEERS

COUNTERMEASURE-PROOF AIRBORNE COMMUNICATIONS

...one of many exciting programs with long-term importance attracting engineers to General Electric's Light Military Electronics Department



Light Military engineers are developing an airborne communications system with ability to maintain efficient operation in the face of intense and sustained electromagnetic interference. Embodying in its design a number of new concepts, this low-weight system possesses long-range capability as well as extreme reliability.

There are Immediate Openings on this Advanced Program

ECM-Proofed Communications afford unusual opportunities for communications systems design engineers to make measurable contributions in the design of the airborne or space terminal. Within this work program there is opportunity to formulate new techniques in RF power generation, modulation and coding, including error correction. Additionally there are challenging openings for engineers with backgrounds in transmitter/receiver design, logic design, RF and digital transistor circuit design, microwave and cavity design.

Other stimulating programs under way at LMED on which a number of professional staff openings are available include Polaris Fire Control and Guidance Computer, ICBM Guidance, Airborne ECM and Airborne Navigation Systems.

*Address your inquiry in complete confidence to:
Mr. Ron Bach, Dept. 60-MA*



LIGHT MILITARY ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

FRENCH ROAD, UTICA, NEW YORK

Check Employment Inquiry Form on Page 193

* DIVERSIFICATION



* Another reason to
JOIN ROHR, the company that's known by the
PEOPLE it keeps!

Diversification means many things to the people who are contributing their talents to Rohr's unchallenged role as the world's largest producer of components for flight. It means a variety of interesting assignments and the opportunity for personal growth and professional expression. Diversification has led to Rohr's record backlog of nearly a quarter billion dollars — 64 percent in *commercial* contracts — assuring unparalleled stability.

Rohr's diversification is symbolized by the jet power package pictured above, containing 5000 Rohr-built parts, and the Rohr-developed honeycomb brazing process shown below . . .

Rohr invites inquiries from men who can contribute to the company's continued leadership in the aerospace industry. Write to Mr. J. L. Hobel, Industrial Relations Manager, Rohr Aircraft Corp., P.O. Box 878-E, Chula Vista, California.



WORLD'S LARGEST
PRODUCER OF
COMPONENTS FOR FLIGHT



ROHR
AIRCRAFT CORPORATION

Chula Vista & Riverside, Calif.

Check Employment Inquiry Form on Page 193

IMPORTANT

In filling out "Employment Inquiry Form" be sure to print clearly.

When you check more than one company, the

form must be photostated so that each

company receives a

copy.

NEERS
SCIENTISTS



the steps beyond

man's first flight into the space

environment are being designed and developed at REPUBLIC AVIATION

One day in the not too distant future man will be proud to go into orbit and will return to earth safely. Monumental as this exploit will be, the inevitable question will then arise: "What next?"

It is the "what next" that is being answered today at Republic Aviation where research and development is focused on the future. A short orbital flight or a brief landing on the moon will never satisfy man's curiosity or his needs. Space must be further explored and its secrets more fully understood so that some day man can freely traverse its vast distances.

Republic Aviation is proud of the part it is playing to make man's greatest adventure successful. Here every aspect of space technology is under active investigation. A few of the challenging programs now underway include:

- Unique guidance systems for manned space vehicles
- Plasma and nuclear propulsion systems
- Space vehicle materials and processing techniques
- Control systems that remain efficient at temperatures in excess of 1500°F
- Studies in low-pressure plant growth for lunar base application
- Super-accurate space vehicle trajectory studies

All of these programs — and many others — are being substantially augmented with a view toward the early occupancy of Republic's new \$14 million Research and Development Center.

Senior engineers or scientists with superior skills and a desire to pioneer in research so that man may pioneer in space are invited to inquire about positions in these important areas:

ELECTRONICS

Inertial Guidance & Navigation / Digital Computer Development / Systems Engineering / Information Theory / Telemetry-SSB Technique / Doppler Radar / Countermeasures / Radome & Antenna Design / Microwave Circuitry & Components / Receiver & Transmitter Design / Airborne Navigational Systems / Jamming & Anti-Jamming / Miniaturization-Transistorization / Ranging Systems / Propagation Studies / Ground Support Equipment / Infrared & Ultra-violet Techniques

THERMO, AERODYNAMICS

Theoretical Gasdynamics / Hyper-Velocity Studies / Astronautics Precision Trajectories / Airplane & Missile Performance / Air Load and Aeroelasticity / Stability and Controls / Flutter & Vibration / Vehicle Dynamics & System Designs / High Altitude Atmosphere Physics / Re-entry Heat Transfer / Hydromagnetics

PLASMA PROPULSION

Plasma Physics / Gaseous Electronics / Hypersonics and Shock Phenomena / Hydromagnetics / Physical Chemistry / Combustion and Detonation / Instrumentation / High Power Pulse Electronics

NUCLEAR PROPULSION & RADIATION PHENOMENA

Nuclear Weapons Effects / Radiation Environment in Space / Nuclear Power & Propulsion Applications / Nuclear Radiation Laboratories

Send resume in confidence to: Mr. George R. Hickman
Engineering Employment Manager, Dept. 1A-5



REPUBLIC AVIATION

Farmingdale, Long Island, New York



ELECTRONIC ENGINEERS

STAVID

offers all 3 most important position considerations:

CAREER OPPORTUNITIES based on solid, long-term growth . . .

TOP EARNINGS fully commensurate with experience . . .

CHALLENGING ASSIGNMENTS made possible by project diversification.

STAVID has immediate openings in career opportunities in airborne, shipboard and ground-based systems and equipment. Degree or graduate degrees, Electrical or Mechanical Engineering, Physics or Math. Positions available at all levels in research, design, development and field service engineering.

WEAPONS SYSTEMS

- Feasibility Studies
- Advanced Designs
- Countermeasures
- Systems Analysis
- Missile Guidance
- Bombing & Navigation
- Logic Design
- Data Transmission
- Display Development
- Missile Detection
- Applied Mathematics

RADAR SYSTEMS

- High-Power Modulation
- UHF & VHF Development
- Antennas
- Receivers & Transmitters
- Transistor Applications
- Microwave Development
- Digital Techniques
- Electro-Mechanical Packaging
- Pulse Circuit Techniques
- Telemetry
- I.F. & Video Circuitry
- Environmental Testing



STAVID's facilities in Plainfield, New Jersey, at the foothills of the Watchung Mountains, are near excellent schools, modern shopping facilities and ample housing accommodations. With New York City just 45 minutes away, and the New Jersey shore within one hour's drive, the Plainfield area provides an ideal environment for work, recreation and comfortable suburban living.

For complete details, please send detailed resume to:

J. R. CLOVIS, Personnel Department SA-12

STAVID Engineering, Inc.

U.S. HIGHWAY 22, PLAINFIELD, NEW JERSEY PLAINFIELD 7-1600

Imaginative Electronics

A Subsidiary of LOCKHEED AIRCRAFT CORP.



Check Employment Inquiry Form on Page 193

Investigating

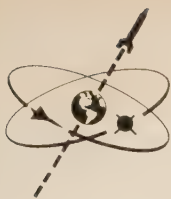
Employment

Opportunities?

Want more information about employment opportunities offered by companies advertising in this issue? Then be sure to give complete data about your job interests, experience and education when filling in the "Employment Inquiry" form.

Although not an application for employment, it provides employment managers with information to evaluate your capabilities — and in turn give your request immediate consideration.

Check the "Employment Inquiry" form for details.



product index to advertising

THIS IS A SPECIAL REFERENCE to the product information given in the advertisements in this issue. It is intended solely to help the reader make the best use of these ads. Therefore the index does not necessarily cover all the products made by each advertiser. Also, definitions and cross-listings are not intended to exhaustively describe each product but merely to make sure that each product can be found with reasonable ease by the reader looking for it.

Similar indexes to services and employment opportunities featured in ads follow this index.

Advertisements for which complete proofs were not available to the Editorial Department by the closing date are not necessarily covered by these indexes. (Proofs can be forwarded internally by the Production Department only for advertisements meeting the closing dates.)

For more detailed information on any product or service advertised in this issue or featured in its Product and Data Reviews, use the handy Reader Service Card.

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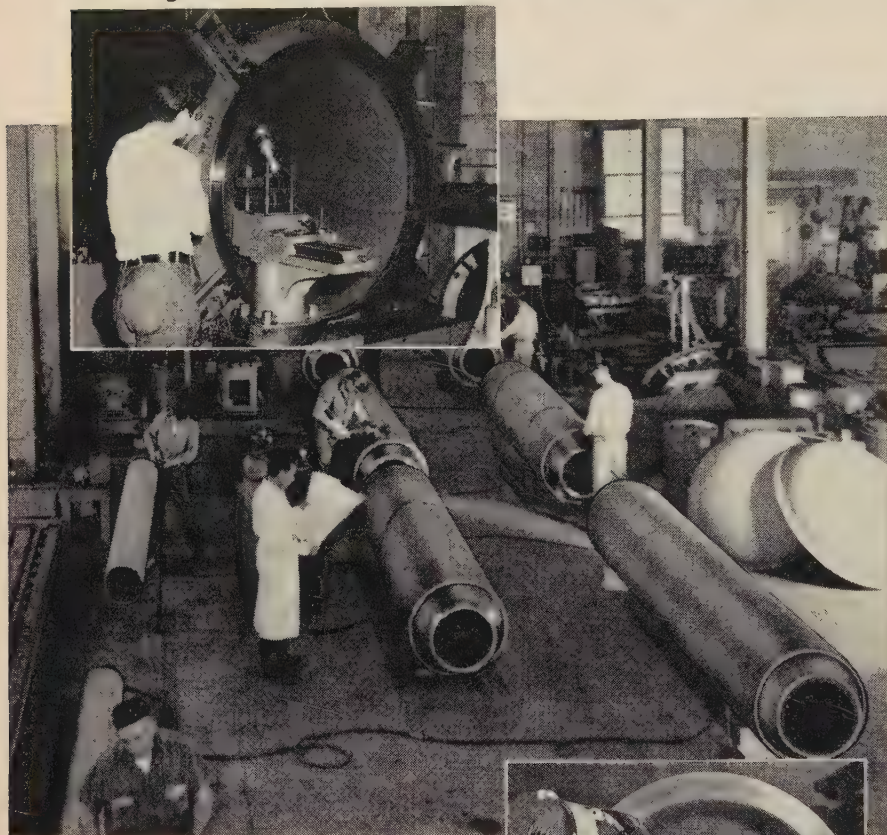
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Missile Hardware by **NEWBROOK**



- **MOTOR CASES**
Solid and Liquid Propellants
- **JATO CASES**
- **NOZZLES**
- **PLENUM CHAMBERS**
- **BLAST TUBES**
- **FUEL INJECTORS**

Newbrook has and is producing Missile motors and space hardware, for such programs as the Minute-Man — Polaris — Nike — Zeus and Sergeant as well as the current space capsule re-entry rocket and many other classified programs.

If you have a need for high strength thin wall rocket motor cases and nozzles we will be pleased to quote on your requirements. Our welding facilities have been set up to handle the new high carbon steels.



Newbrook has developed techniques in machining and welding high carbon steels that can be most effective in the fabrication of your future missile components.

Newbrook

MACHINE CORPORATION

SILVER CREEK

NEW YORK

Write in No. 117 on Reader Service Card at start of Product Preview Section

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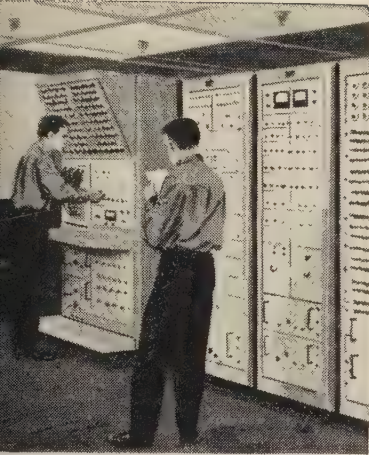
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SPACE/AERONAUTICS

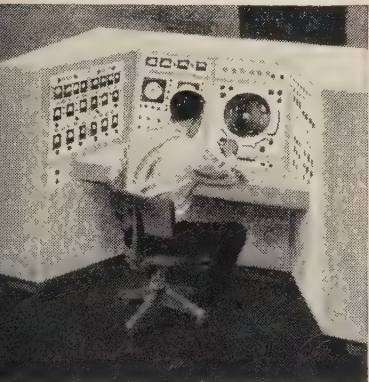
In 1936—air defense by **SPERRY**



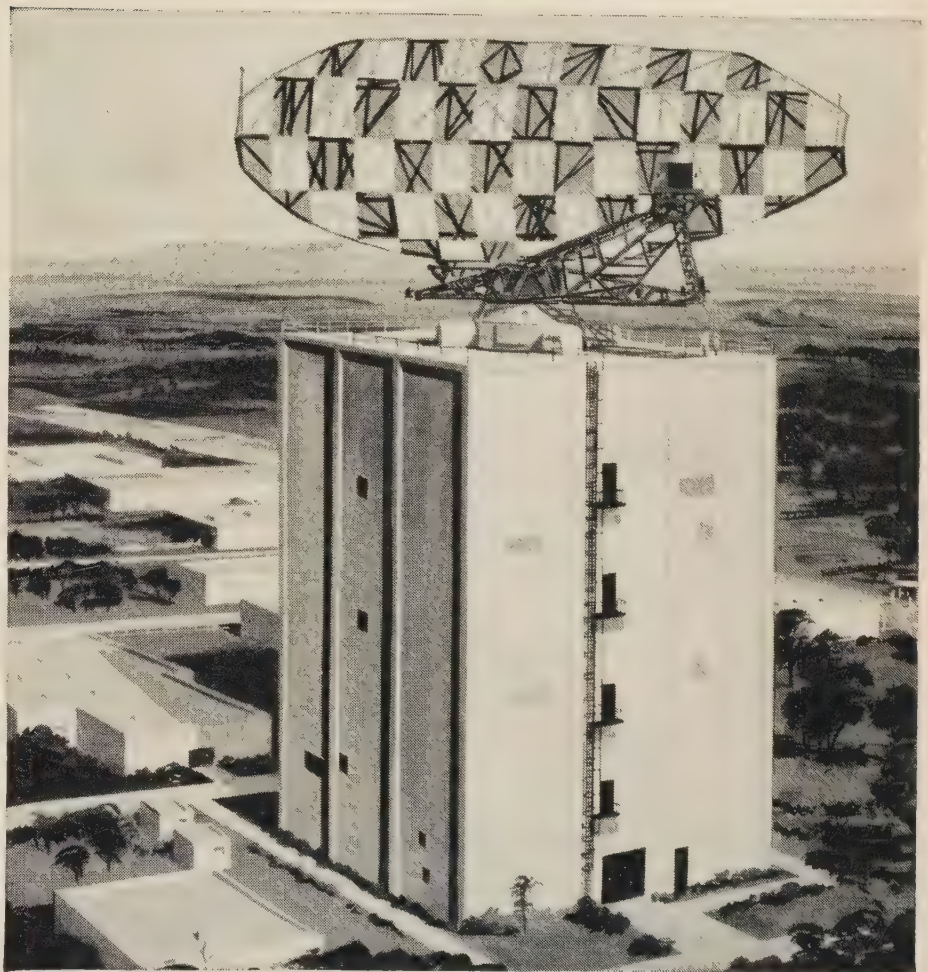
Before the invention of radar, Sound Locators aided the human ear in sensing the approach of aircraft.



HIGH SPEED COMPUTERS housed in towers calculate target information from radar and provide intercept-destroy data.



CONTROL CENTER OF OPERATIONS for FPS-35 installation is MAJAC—Monitor, Anti-Jam and Control Console.



TOWER OF STRENGTH in U. S. defenses, area search radars by Sperry will be spotted strategically throughout main Air Force defense networks.

Giant Sperry Search Radar To Strengthen U. S. Air Defenses

First fortress-like radar is "on the air" only 19 months after contract

ew, high-powered area defense search radars housed in giant concrete "fortress" towers—are taking their place in America's vast chain of air defense systems. The first such tower was constructed at Thomasville Aircraft Control and Warning Station in Alabama. These radars (AN-FPS-35), developed by Sperry's Surface Armament Division in close cooperation with AF's Rome Air Development Center, will become part of the Continental Aircraft Control and Warning System which searches out cruise-type missiles and aircraft.

The giant antenna assembly, weighing nearly 70 tons, is situated on a concrete tower 85 feet high and 60 feet square. The radar feeds target position information into high speed computers, which in turn work out involved calculations for interception and destruction of the target by missile weapon systems. The tower houses the full complement of men and equipment necessary to sustain continuous operation. Strategic sites in the U. S. defense network have already been selected for location of additional search radar systems.

This "tower of strength" in U. S.

defenses underlines Sperry's advanced capabilities in radar—the result of experience dating back to radar's earliest beginnings and highlighted by many significant Sperry contributions to the science.

SPERRY

SURFACE ARMAMENT DIVISION, SPERRY GYROSCOPE COMPANY, DIVISION OF SPERRY RAND CORPORATION, GREAT NECK, NEW YORK

Write in No. 118 on Reader Service Card at start of Product Preview Section

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**LOWER IN COST
SUPERIOR IN DESIGN**

The Whittaker SUB-MINIATURE

Here is the Sub-Miniature Rate Gyro that represents a genuine advance in the design of guidance components.

Substantially *lower cost and greater reliability* is made possible by a uniquely superior design which eliminates damping fluid and danger of leakage. Linear damping is provided by a permanent magnet eddy-current damper.

The Whittaker Sub-Miniature Rate Gyro has a *faster*

start time than any other known gyro of its type. Performs reliably from -65°F to 200°F and extended ranges can be supplied. Gyros designed to your exact requirements are available in short delivery time.

Whittaker Gyro provides you with superior design at lower cost... truly a Miracle in Miniaturization!

For complete technical data, write for Product Brochure No. SM 1.14.

WHITTAKER GYRO HAS PRODUCED MORE THAN 400,000 GYRO INSTRUMENTS, MANY OF THEM FOR MAJOR MISSILE PROGRAMS. ALL WG PRODUCTS ARE THE RESULT OF:
 • BETTER DESIGN CONCEPTS • CONSTANT ATTENTION TO DETAIL • QUALITY CONTROL THAT IS SECOND TO NONE • CONSTANT R & D FOR PRODUCT IMPROVEMENT

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ATE GYRO

Miracle in Miniaturization!

WHITTAKER GYRO

Division of TELECOMPUTING CORPORATION

16217 Lindbergh Street, Van Nuys, California

Phone: TRiangle 3-1950

WHITTAKER GYRO

"Your Guide to Better Flight Control Systems and Components"



WHITTAKER GYRO: Leading designer and manufacturer of electromechanical and non-electric gyroscopes, including rate gyros, vertical gyros, and position gyros. In addition, this Division is active in the sub-systems field with stable platforms, inertial guidance equipment, and auto pilots for missiles.



WHITTAKER CONTROLS: Designs and produces aircraft and missile fluid control systems, sub-systems and components. WC Products are in every production military aircraft and commercial airliner. In many of the nation's missile programs, Whittaker is also solving extreme fluid control problems.



MONROVIA AVIATION: Producers of precision aircraft structural assemblies, Monrovia Aviation's products are installed on America's principal military and commercial jet aircraft. This Subsidiary also designs and manufactures customized portable air conditioning units for missile ground support purposes.



TELECOMPUTING SERVICES: Skilled in the establishment and operation of data processing centers, primarily for military and civil agencies of the Government. At White Sands Missile Range, TSI processes and analyzes missile test data. At Vandenberg AFB, this Subsidiary provides data processing services for SAC's 1st Missile Division.



ELECTRONIC SYSTEMS: Specialists in systems management, this Division also designs and manufactures a wide variety of equipment in the fields of electronics and nucleonics for highly classified Military Programs. In addition, Electronic Systems designs and produces Air Traffic Control equipment for the Federal Aviation Agency.



DATA INSTRUMENTS: Leading designer and producer of data reduction systems for ground support and range instrumentations. Product line includes shaft rotation digital equipment, decommutators, and other highly complex and specialized instruments for missile and aircraft testing, telemetering and in-flight operation.



ELECTRONIC COMPONENTS: Designs and produces components, including magnetic amplifiers, transformers, micro-miniature relays, delay lines and high temperature ceramic capacitors. These reliable components are being selected for installation in many of the country's principal missile and space programs.

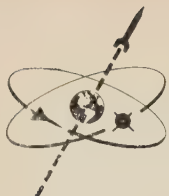


COOK BATTERIES: Designers and manufacturers of automatically and manually activated silver-zinc batteries for specialized missile application. These auxiliary power units provide primary or secondary electrical power. This subsidiary also produces power conversion and other electronic apparatus.

Telecomputing Corporation is a unique combination of carefully integrated organizations. It is staffed with scientific talent of rare ability, created for the purpose of managing entire Space Technology and Weapon System Projects. Telecomputing is developing *advanced concepts* in industrial and military control systems.

TELECOMPUTING CORPORATION

Los Angeles, California



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Official United States Navy Photograph

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being equipped with the most
advanced sonar system ever devised.
Raytheon—working closely with the Navy—
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RAYTHEON COMPANY, WALTHAM, MASS.



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open a gate

no matter
where it is

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provides greater
dimension in
telemetry, flexibility,
and reliability.*

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TDS
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200**

Arnoux's Decommutator Series 200 continues to operate with one or even all information gates removed; active readout capability is from 1 to 88 channels, operating on all standard IRIG sampling rates of 30, 45, 60, or 90 channels at from 75 to 900 pps. All output patching and cross-strapping provided internally.

This new Decommutator uses a new gate-pulse generator, the DGG-1, which has a wide-range rate capability and can be adapted for any system requiring sequential gate pulses. Economy and smallness—the DGG-1 is only 3½ inches high and mounts in a standard rack. Selection of operating mode is by front-panel pushbuttons. A visual channel quantity counter is provided for proper system synchronization check. BULLETIN 801.

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DECOMMUTATORS

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CHANCE **VOUGHT CRUSADER**
DALLAS, TEXAS

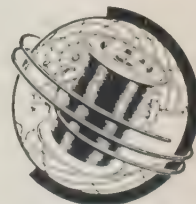
Operating from fast, far-ranging carriers, the new F8U-2N Crusader adds even greater strength to the U. S. Fleet. This all-weather fighter is fully instrumented and equipped to deliver the deadliest of air-to-air missiles . . . at speeds approaching Mach 2.

Chance Vought again specified Hitemp Teflon* wire and cable for use in the F8U-2N—their fourth operational version of this fighter to be delivered to the U. S. Fleet.

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*Registered trademark for Du Pont fluorocarbon resins.

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Clearing Reports on

Five current projects on MECHANICAL EQUIPMENT for oceanographic research

***FOIF—Free Oceanographic Instrument Float.** Now undergoing deep sea testing, this float follows a free flight trajectory to the depths and return. By freeing the instrumentation from its connection to the mother ship, data gathering is far more efficient and faster.

GRAPPLING SYSTEMS. A self propelled, remotely controlled grappling device for ocean floor work. Utilizing closed circuit television and light arrays, the oceanographer can search out and gather samples selectively with this mechanical hand. Also, suitable for attachment to bathyscaphes and deep diving submarines.

DUMS—DEEP UNMANNED SUBMERSIBLES. A new self propelled, deep diving unmanned submersible which follows a pre-set course to any depth for durations of four hours. Consisting of a fiber glass case and self contained jet drive power package, DUMS will collect data throughout large volumes of the ocean.

DEEP CORING DEVICE. Using a new principle in coring, this deep self powered corer can obtain long undisturbed cores of the basin sediments. Dropped freely, or cable lowered, the corer will level itself, collect a 200 ft. sample from one location in a vertical direction, and then return to the surface.

CONSTANT TENSION WINCHES. This research winch holds a constant tension in the cable thus eliminating tension and depth fluctuations caused by ship reaction to wave motion. By utilizing a new servo controlled hydrostatic drive, cable breakage and depth holding problems are minimized.

* * *

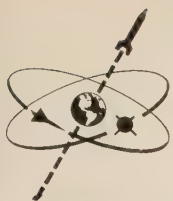
Components for Bathyscaphes and Deep Diving Submarines • Deep, Fiber Glass Floats • Fiber Glass Pressure Cases for A.S.W. and Oceanographic Research

Call on Research and Development

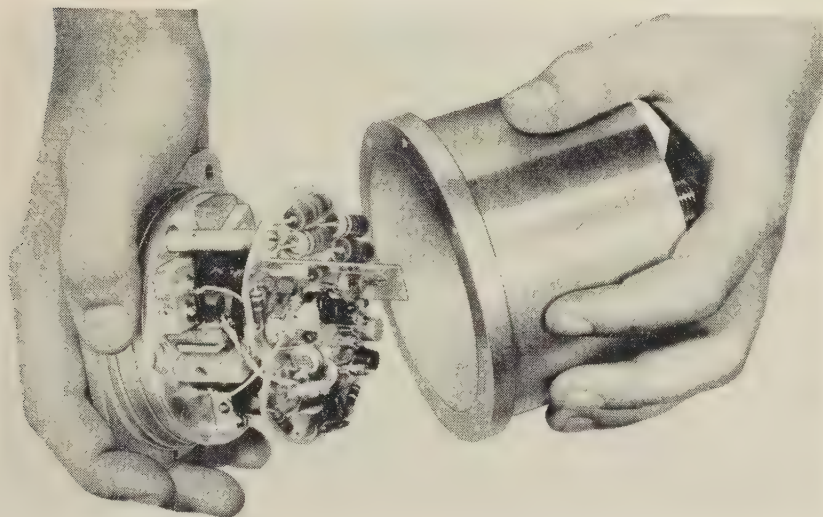
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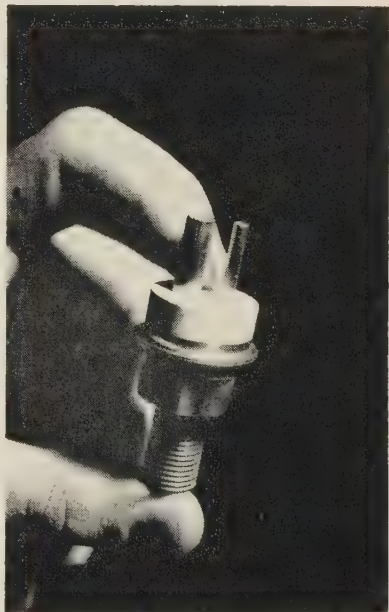
SEISMIC ANGULAR ACCELEROMETER

EXPENSIVE gyro devices can sometimes be eliminated in pitch, yaw, and roll monitoring if you use its new angular accelerometer, claims Donner Scientific Co., Concord, Calif. The accelerometer operates as a subminiature servo system responding to input angular acceleration about its sensitive axis. It combines a seismic system with a position-error detector, a restoring mechanism, and a servo error signal amplifier.

Angular acceleration exerts a force on the seismic system, which in turn tends to develop a displacement. As movement takes place, the position-error detector produces a rapidly increasing feedback signal. After amplification, this signal is returned as current through the restoring mechanism. Even for minute deflections of the seismic system, the accelerometer automatically balances the input

force (proportional to acceleration) and the feedback force (proportional to the current in the restoring coil). The restoring current, or the voltage it develops across a fixed-load resistor, precisely indicates the input acceleration.

The accelerometer is available from ± 1 rad/sec² to ± 50 rad/sec² as well as for any intermediate range. With 90 deg lag, frequency response is ± 1 rad/sec² for 30 cps natural frequency and ± 10 rad/sec² for 100 cps. Other characteristics: full-scale output, ± 20 V across a 12.5-K load; resolution, 0.01 per cent of full scale or better; linearity, 0.1 per cent of full scale; hysteresis, less than 0.01 per cent of full scale; damping, 0.6 ± 0.1 of critical. The hermetically sealed assembly weighs two pounds and is 3.7 in. high and 3.7 in. in diameter. Write in No. 71 on Reader Service Card for more data.



house expects that quantities will be available soon.

Suited for high power switching and linear power applications, the transistors have the following characteristics: collector-to-emitter voltage ratings, 30-200 V; maximum operating junction temperature, 150 deg C; saturation resistance, less than 0.1 ohm. With a minimum current gain of 10-15 amp of collector current, the maximum collector current rating is 30 amp.

Because of the higher temperature capabilities of silicon, one of these devices can be used where previously you needed a number of germanium units in parallel. With a low thermal drop from junction to case added to their higher temperature capability, these power transistors dissipate up to 250 W internally.

Gunther notes that the forerunner of the present device, a five-ampere silicon transistor, makes a suitable driver for the new 30-amp device. He also suggests that in addition to high power switching, the transistors can be used in high power dc-ac and ac-dc converters, dc-ac inverters, high power dc current and voltage regulators, and high power linear amplifiers. Write in No. 70 on Reader Service Card for more data.

HIGH POWER SILICON TRANSISTOR

A NEW type of high power silicon NPN transistor, developed by Westinghouse Electric Corp., P. O. Box 2278, Pittsburgh 30, Pa., reportedly can control over five kw of power when used as a switch. According to D. W. Gunther, man-

ager of Westinghouse's Semiconductor Dept., his engineers have come up with "the highest power transistors, in either germanium or silicon, that have yet been developed." The transistors are still in the prototype stage, but Westing-

Write in No. 123 on Reader Service Card



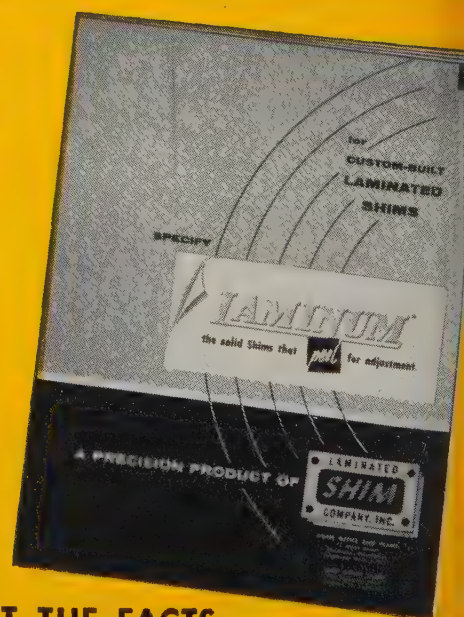
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No stand-by equipment. No machining. No grinding. No counting. No stacking or miking. And no grit between layers—ever. *That's* what saves time! And cuts costs!

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STEPPING MOTOR increases torque threefold



JANUARY 1960

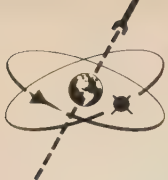
G. H. Leland, Inc., 123 Webster Street, Dayton 2, Ohio, has designed a high-precision stepping motor that can develop at least three times more torque than comparable motors, it is claimed. The "Syncramental" motor is 1½ in. long, weighs 4-13 ounces, is available in unidirectional and bidirectional models, and has angular increments of 36 deg per pulse, up to 15 steps per second, and a load capacity of up to two pound-inches starting torque.

It is used to rotate potentiometers, counters, rotary switches, tape advances, and other control mechanisms. A clutch mechanism, used instead of ratchets, allows the translation of pulses to incremental shaft positions with 99.999 per cent accuracy and dependability. Each Syncramental motor is pre-tested over 50,000 steps in each direction, and the probability of missing a step is only one in 1,000,000, according to the company.

Write in No. 125 on Reader Service Card at start of Product Preview Section

This award is made in recognition of outstanding service performed through the development and manufacture of a product contributing to the advancement of the aerospace industry.

Randolph Hawthorne
Editor



product preview

DECIMAL DECODER for in-line display



Types BCD-8421 and BCD-4221 are designed to take the respective binary coded parallel information directly to the input of a Beam Switching Tube and display the equivalent decimal information on a Nixie in-line indicator tube, says **Burroughs Corp., Electronic Tube Div., Dept. S/A, Box 1226, Plainfield, N.J.**

Features of the printed circuit plug-in modules include display repetition rates in excess of 1 Kc and their ability to supply useful decimal outputs.

Write in No. 335 on Reader Service Card

DC RELAY has removable case

This series 5 D1C relay, dc operation, has a polystyrene enclosed plug. Its removable case permits field adjustment without special equipment, says **Kurman Electric Co., Dept. S/A, 191 Newel St., Brooklyn 22, N. Y.**

Mounting: 8 pin octal plug-in. Coil resistances of 500-13,000 ohms.

Write in No. 378 on Reader Service Card

VOLTAGE METERS have go/no-go indication



The Voltage Indicator provides the operator with a go/no-go indication and can be programed to represent a wide range of voltages, says **Voltron Products, Dept. S/A, 1010 Mission St., So. Pasadena, Calif.** The accuracy of this unit is 0.25 per cent for dc and 0.5 per cent for ac.

A variant of this unit, is a voltage comparator called the Voltrip having a relay and amplifier substituted for an indicating meter.

Write in No. 336 on Reader Service Card

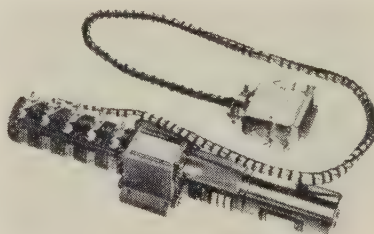
SOLENOID operates at 1000 deg F

This new solenoid, designed for aircraft and missile applications, operates continuously at ambient temperatures up to 1000 deg F, says **Rocker Solenoid Co., Dept. S/A, 140 N. Marine Ave., Wilmington, Calif.** The high rating is reported to result from a new method of coil and bobbin manufacture.

Stroke ranges from .010 to .060 in. and at .010-in stroke (1000 deg F) the 1.3-lb unit will operate a minimum force of 15 lbs. Power source required is 18 to 30 Vdc. Standard and special mounting configurations are available.

Write in No. 337 on Reader Service Card

SERVOPACKAGES for in line assemblies



This in-line servopackage is compact and space-saving modules free the designer from positioning, testing matching and aligning individual components, says **Beckman Instruments, Helipot Div., Dept. S/A, Fullerton, Calif.** Size 11 system module consists of 115v, 400 cycle servomotor-rate generator; gearhead; mounting pad; five ganged model 5203 single-turn potentiometers; and AN connector. Unit measures 7 3/4 x 1 3/4 x 1 1/2 in.

Stall torque of the generator unit is 0.6 oz in; rotor inertia 1.1 gm. mc²; acceleration at stall 38,500 rad/sec²; and power input 3.9 watts.

Write in No. 338 on Reader Service Card

DUAL FILTER signals clogging

A dual filter, No. 52-2290-000, which actuates a signal when it is being clogged places a secondary filter in operation. This action permits an aircraft to go on and complete its mission before the fuel by-pass opens, according to **Aero Supply Mfg. Co., Inc., Dept. S/A, Corry, Pa.** Design includes reusable filters, visual determination of filter cleanliness, adaptability of design to various line sizes, fluids and temperatures.

Filtration rating of the unit is 70 microns.

Write in No. 339 on Reader Service Card

PICK-UP STORAGE TUBE has high resolution



The Permacohn, a small size pick-up storage tube Type WX3989 for high resolution, long storage, continuous read out applications, has optical pick-up capabilities comparable to a Vidicon and will operate in a standard vidicon camera. Resolution of the stored image is exceptional, says **Westinghouse Electric Corp., Dept. S/A, Box 227, Pittsburgh, Pa.**

The tube incorporates a new storage material which will retain a stored charge pattern while it is scanned by an electron beam. Using a standard television scan rates, as many as 2X10⁵ electrical images may be taken from a single exposure. Resolution of 600 television lines and 8 shades of grey are maintained for possibly 5 minutes.

Write in No. 340 on Reader Service Card

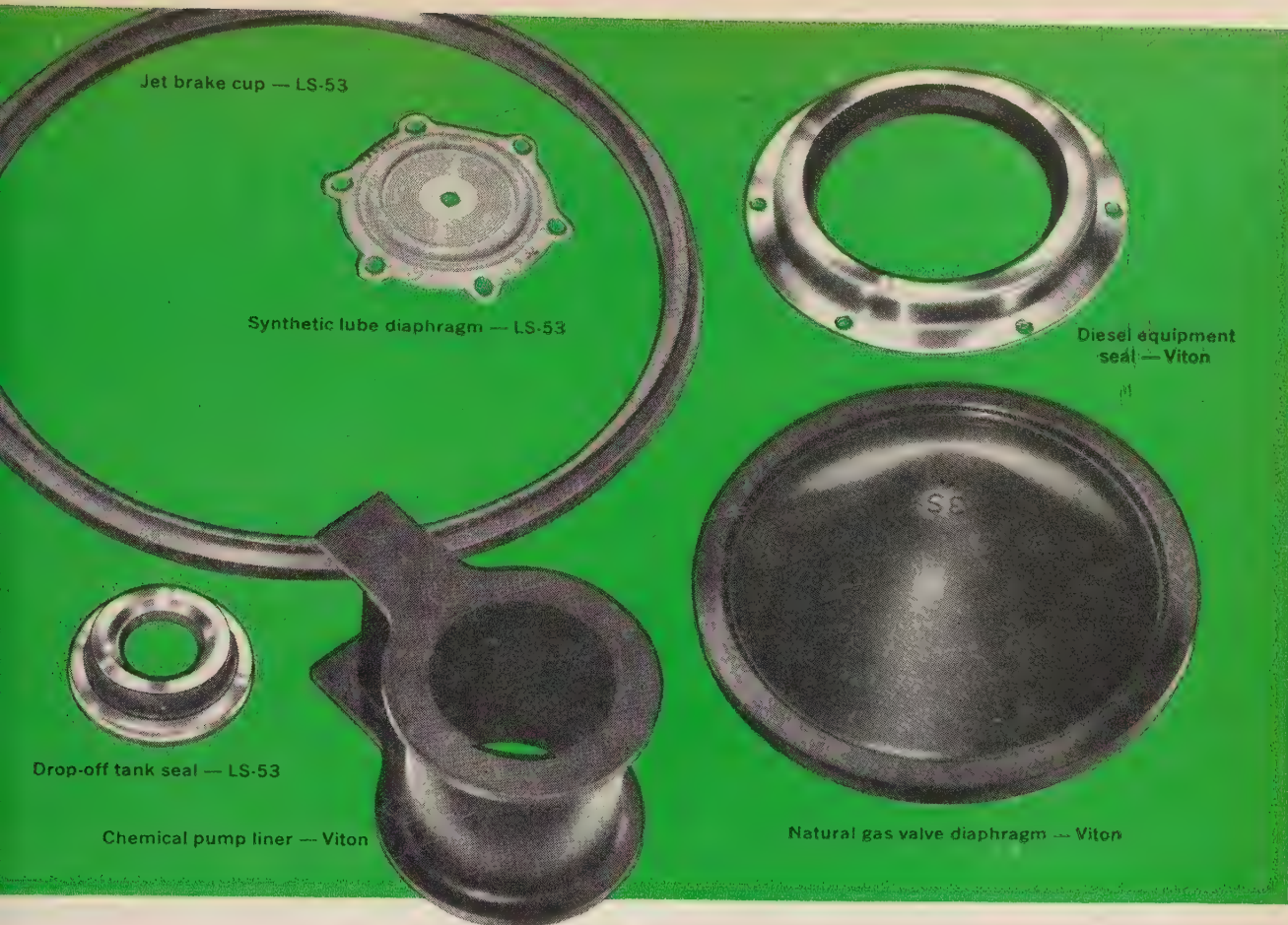
LOW-PASS FILTER is efficient

The TLP-4A Series of low-pass RF filters are miniature units that provide over 50-db attenuation at 1.5 times the cut-off frequency, says **Telonic Engineering Corp., Dept. S/A, Laguna Beach, Calif.** The filters cover the range from 200 to 1000 mc, with cut-off frequencies in five-mc increments; cut-off frequency is the point at which insertion loss exceeds 1.5 db.

Applications include filtering the output of oscillators and other RF sources, and the device is said to enable missile guidance system designers to meet interference specifications with a minimum of hardware complexity. The device is also suited to missile applications because of small size and ruggedness. Lengths vary from 1 1/2 to 2 1/2 in., and diameter is under 3/8 in. The filters may be obtained with various end connections.

Write in No. 341 on Reader Service Card

more on page 224



For advanced fuel...hydraulic...lube systems,

New materials prove ideal in handling

temperature extremes -350°F. to $+750^{\circ}\text{F.}$

Working with two remarkably versatile elastomers, C/R Sirvene engineers are producing flexible molded parts for many vital fuel, lubricating, hydraulic and pneumatic systems. One, Viton-A*, can be compounded to produce parts that function dependably at 600°F. , and for short periods up to 750°F. The other important feature of Viton compounds is their excellent resistance to corrosive chemicals, chlorinated solvents as well as both synthetic and petroleum base fuels and lubes. At the other extreme, C/R compounded Silastic LS-53** parts are providing low temperature operation down to -80°F. They also exhibit excel-

lent resistance to synthetic and petroleum base fluids up to 350°F. , and function well in propane up to 500°F. For temperatures as low as -350°F. , C/R recommends Teflon* compounds.

C/R Sirvene engineers have an intimate knowledge of these elastomers. They also have perfected special techniques in processing which still further improve the physical properties of the molded parts. If your problem involves high or low temperatures, close tolerances, and compatibility in advanced design fuel, lubricant or hydraulic systems, get in touch with us at once. We have the skill and the facilities to help you.

* DuPont registered trademark

**Dow-Corning registered trademark

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Export Sales: Geon International Corp., Great Neck, New York

C/R PRODUCTS: C R Shaft & End Face Seals • Sirvis-Conpor mechanical leather cups, packings, boots • C/R Non-metallic gears

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an expert in

HOT GAS VALVES?

Aero Supply designs and manufactures all types of relief valves, solenoid valves, pressure regulators, check valves, and filters to handle products of combustion. Request Bulletin 12-959 and our complete capabilities report.

... when they have
fired 1000
successfully ...

**WE
HAVE!**



SHOWN
ACTUAL
SIZE



A NEW DEVELOPMENT OF THE



AERO SUPPLY MFG. CO. INC.

CORRY, PENNSYLVANIA

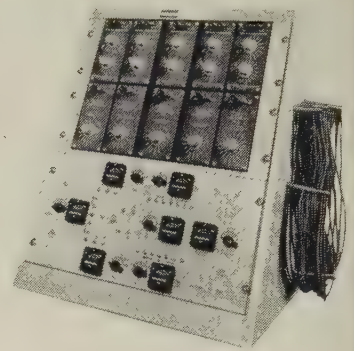
ELECTRO-MECHANICAL DEVICES • PRECISION MANUFACTURING

• ENGINEERED FLUID CONTROL SYSTEMS •

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PRODUCT PREVIEW

BREADBOARD for transistor evaluation

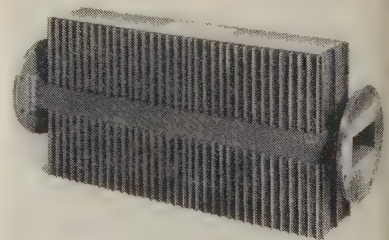


The rapid set-up of design circuits to evaluate transistor characteristics may be achieved with the Model TB-1 transistor breadboard, says **Abrams Instrument Corp., Dept. S/A, 606 E. Shiawassee St., Lansing 1, Mich.** The device permits a check of transistor frequency response and current gain, input and output impedance, cascading, linearity or distortion, and other factors.

Other features include snap-type terminals, and capacitance and resistor substitution boxes. In addition, seven small precision meters permit all current and voltage values to be viewed simultaneously.

Write in No. 342 on Reader Service Card

HARMONIC FILTER is high-power unit



The typical harmonic and spurious signals generated by high-power magnetrons, klystrons and traveling-wave tubes can be suppressed by this high-power harmonic suppression filter developed for microwave radars by **General Electric Co., Dept. S/A, Schenectady 5, N.Y.** It is intended for use in the waveguide line between tube and antenna.

Insertion loss of the filter is over 25 db for all signals from 5400 to 10,000 mc, and below 0.2 db throughout the pass band from 2700 to 3100 mc. The BSWR across both pass and stop bands is under 1.8, and the device can handle power levels up to five mw.

Write in No. 343 on Reader Service Card
more on page 228

SIZE 8

SYNCHROS • SERVO MOTORS • MOTOR TACH GENERATORS

400 Cycle: Many for 125°C operation . . . Higher for special applications

Many Immediately Available From Stock in Small Quantities

SIZE 8



SYNCHROS

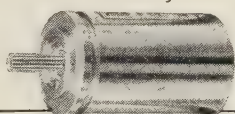
Highly Stable. Minimum Error
Variation from -55°C to +125°C

OSTER TYPE	CLASS	INPUT VOLT-AGE	INPUT CUR-RENT AMPS	INPUT WATTS	OUTPUT VOLT-AGE	PHASE SHIFT (° LEAD)	ROTOR RESIST-ANCE (OHM)	STATOR RESIST-ANCE OHMS	Z _{ro} OHMS	Z _{so} OHMS	Z _{rss} OHMS	NULL VOLT-AGE (MV)	MAX. ERROR FROM E.Z. (MIN.)
4253-01*	LZ-CT	11.8	.087	.21	23.5	9.0	157.0	24.0	212+j722	28+j119	263+j69	30	±7
4269-01*	Diff	11.8	.087	.21	11.8	9.0	35.0	24.0	37+j139	28+j124	47+j13	30	±7
4273-01**	XMTR	26.0	.100	.54	11.8	8.5	34.0	12.0	48+j255	12+j45	82+j31	30	±7
4277-01*	HZ-CT	11.8	.030	.073	22.5	8.5	316.0	67.0	500+j1937	79+j350	594+j182	30	±7
4261-01**	Resolver	26.0	.043	.39	11.8	15.0	162.0	22.0	208+j612	34+j159	243+j77	30	±7

Stator as Primary

**Rotor as Primary

SIZE 8



SERVO MOTORS

OSTER TYPE	RATED VOLTAGES	Z = R + j X	IN. OZ. STALL TORQUE	RPM NO LOAD SPEED	WATTS PER PHASE	GM. CM. ROTOR INERTIA	LENGTH IN. MAX.	WEIGHT OZ.	T/I RATIO RAD/SEC²
5004-01	26V 26V	288 = 226 + j 176 294 = 238 + j 174	.15	6200	2.0	.47	0.863	1.2	22,500
5004-02	26V 36V	288 = 226 + j 176 526 = 409 + j 332	.15	6200	2.0	.47	0.863	1.2	22,500
5004-03	26V 40V	288 = 226 + j 176 715 = 582 + j 415	.15	6200	2.0	.47	0.863	1.2	22,500
5004-09	26V 40V	230 = 190 + j 131 519 = 399 + j 332	.20	6200	2.5	.47	0.863	1.2	30,000

SIZE 8



MOTOR TACH-GENERATORS

OSTER TYPE	RATED VOLTAGES	Z = R + j X	IN. OZ. STALL TORQUE	RPM NO LOAD SPEED	WATTS PER PHASE	GM. CM. ROTOR INERTIA	LENGTH IN. MAX.	WEIGHT OZ.	T/I RATIO RAD/SEC²	GENERATOR VOLTAGE	INPUT WATTS	OUTPUT VOLTS PER 1000/RPM
6204-01	26V 40V	230 = 190 + j 131 519 = 399 + j 332	.20	6000	2.5	.65	1.728	2.5	21,800	26	2.5	.25
6204-03	26V 26V	230 = 190 + j 131 230 = 190 + j 131	.20	6000	2.5	.65	1.728	2.5	21,800	26	2.5	.25

Oster®

The Size 8 400 Cycle Servo Motor Tach Generators listed above have 150° max. cont. frame temperature, 110 MA input current, ±5° phase shift and Null Voltage (Total R. M. S.) of 15 millivolts.

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Here is Aldrich Zmeskal, Manager of Balloon Engineering, observing the launching of another General Mills balloon—one of thousands which we and our customers have flown in the past few years. This routine flight was for the



purpose of obtaining samples of radioactive material from the stratosphere. Through our balloon research projects, we have amassed a considerable fund of knowledge valuable to future space flight.

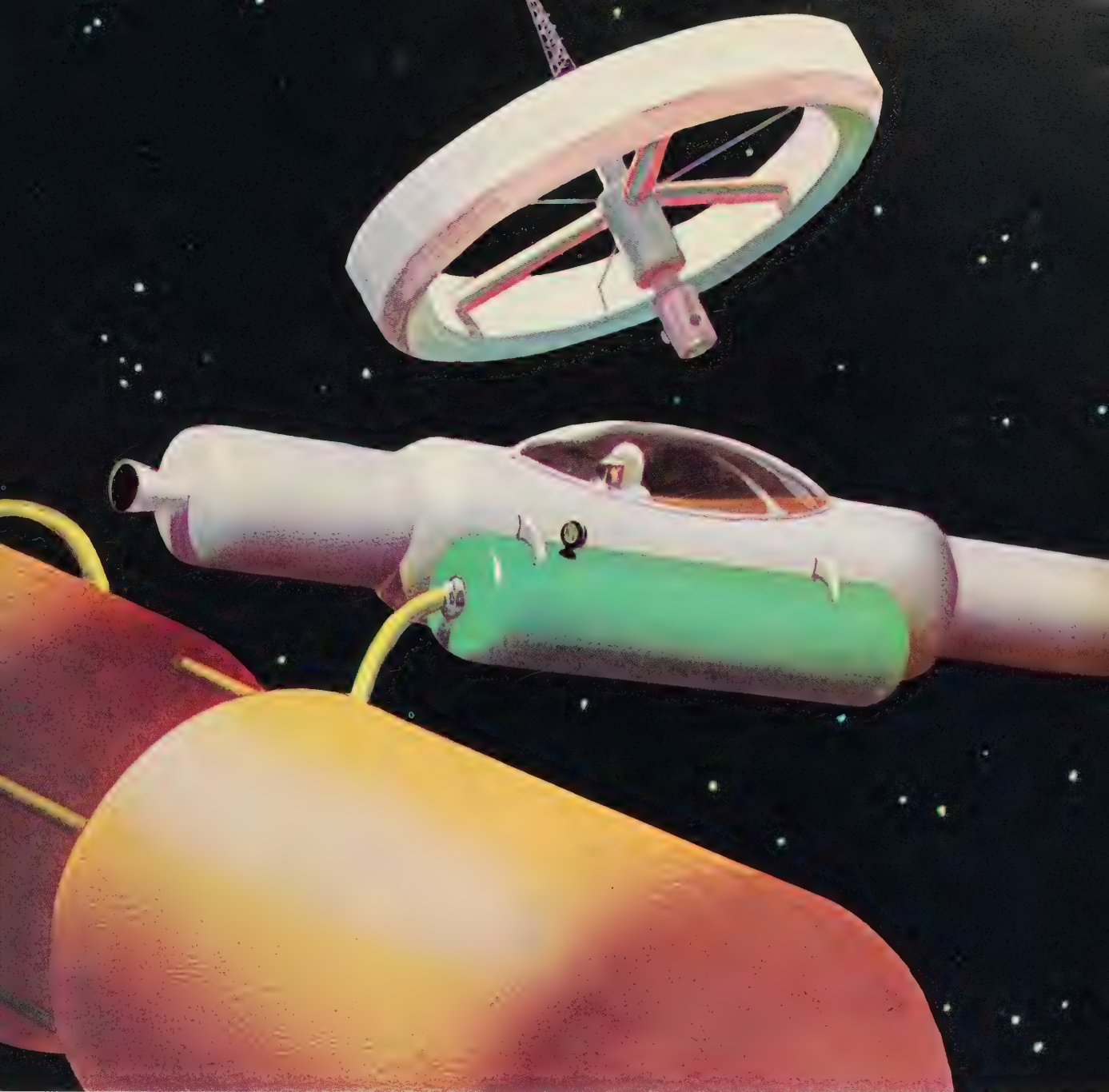
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The Mechanical Division provides "floating laboratories," balloons carrying heavy payloads of equipment—and even men—to altitudes above 95% of the earth's atmosphere. This is a relatively easy and inexpensive way to obtain the knowledge which will enable man to travel in space.

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studies representative of these activities are: ions in vacuum, deuterium sputtering, dust erosion, magnetic materials, stress measurements, surface friction and phenomena, trajectory data and infrared surveillance.

In our engineering department, current projects include: specialized inflatable vehicles and structures, airborne early warning systems, micro wave radar test equipment, antennas and pedestals, infrared and optics,



Orbital vehicle refueling in space . . . illustration from book written for General Mills by Willy Ley.

to make space travel a fact **tomorrow**

inertial guidance and navigation, digital computers—and many other activities.

Our entire manufacturing department is geared to produce systems, sub-systems and assemblies to the most stringent military requirements. Our people have a wealth of

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PRODUCT PREVIEW

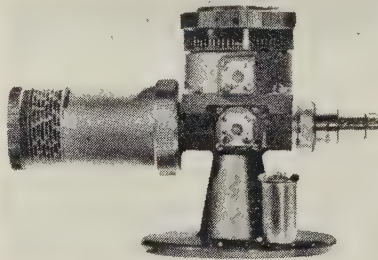
PRESSURE PICKUP has external adjustment

This chamber-type unbonded strain gage pressure pickup retains its accuracy at pressures to 10,000 psi absolute or sealed gage. It has provisions for adjustment of bridge balance, temperature compensation, and sensitivity in a chamber isolated from the sensing element, says Consolidated Electrodynamics Corp., Transducer Div., Dept. S/A, 360 Sierra Madre Villa, Pasadena, Calif. Each pickup can be adjusted to the performance specifications of the user without affecting the precision sensing element.

It uses a spring-type sensing element with four active arms mounted to a force-summing diaphragm.

Write in No. 344 on Reader Service Card

STANDING WAVE DETECTOR permits direct reading



Type 219 Standing Wave Detector permits direct reading of reflection coefficient and impedance from 100 to 1000 mcps. It has a residual VSWR of less than 1.03; minimum input signal of about IV at 100 mcps, 0.1 V at 1000 mcps, and a characteristic impedance of 50 ohms, says Polytechnic Research & Dev. Co., Inc., Dept. S/A, Brooklyn, N.Y.

In addition the unit provides direct reading of reactive component sign, adaptability to most coaxial lines and matched load for self-calibration is supplied.

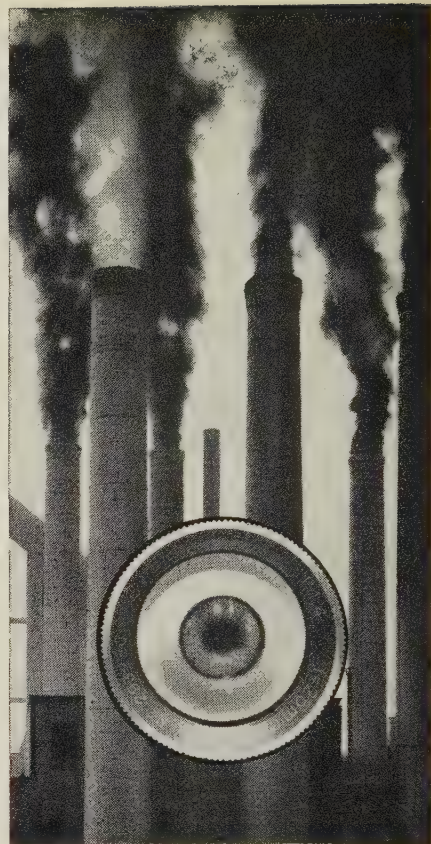
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BRUSH BLOCK for shock, vibration

This series of molded, broom-type brush block assemblies for digitizers, encoders, switching commutators and slip ring assemblies has insulating material that meets MIL-M-14E, Type MDG, capable of operating at temperatures in excess of 400 deg F, says Airflyte Electronics Co., Dept. S/A, 535 Avenue A, Bayonne, N. J. Brushes are grouped in tandem of 3 and 6 wires per track, and are dimpled along a common point of tangency, parallel with the axis of the commutator.

Brush wires are spring temper gold alloy capable of carrying up to 100 mils of current per track.

Write in No. 346 on Reader Service Card
more on page 230

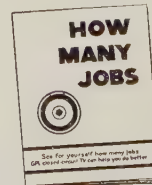


GPL closed-circuit TV fills hundreds of business needs today for such companies as Bell Aircraft, Brookhaven National Laboratory, Chrysler, Consolidated Edison, Convair, Firestone, General Motors, Link Aviation, Martin, New York Savings Bank, U. S. Steel.

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SPACE/AERONAUTICS

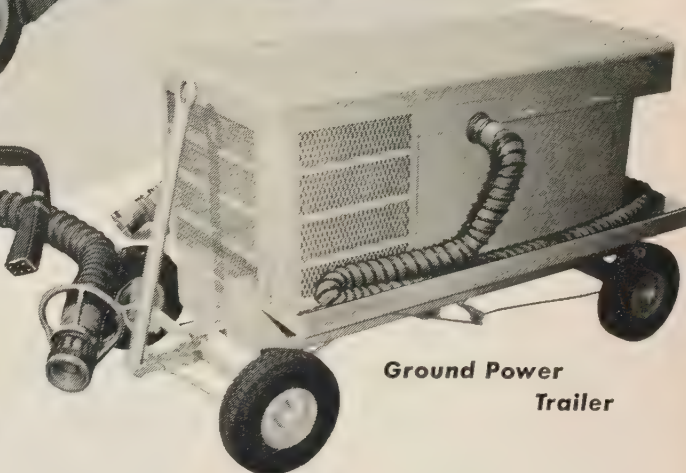
Versatile Ground Support for Jet Transport Fleets



Ground Power Flyaway Unit



Ground Power Vehicle



Ground Power Trailer

8,500 AiResearch Gas Turbine Units in Use

Extremely reliable and diversified, AiResearch mobile ground support equipment provides main engine starting for turbine-powered aircraft, and ground air conditioning and electrical power for both aircraft and missiles.

Heart of the lightweight ground support systems are AiResearch gas turbine compressors which provide pneumatic and/or electrical power. Electrical power is supplied when the unit is coupled with an alternator.

GROUND POWER FLYAWAY UNITS for jet engine starting are designed to meet the need for a mobile low cost pneumatic power source which is readily air portable for

emergency use. These lightweight, self-contained units are mounted on a compact cart complete with instrument panel and enclosure. They can also be used for missile ground support where pneumatic power is required.

GROUND POWER VEHICLES supply both pneumatic and electrical power for jet engine starting, ground air conditioning and other ground requirements where these types of power are needed. Air and electrical connections located at the front of the vehicle allow the operator to drive forward into position. The instrument and control panel are inside the cab, and the power unit is easily accessible through

wide doors on both sides of the vehicle. Full sound attenuation reduces operating sound level below 90 decibels at a distance of 10 feet.

GROUND POWER TRAILERS provide pneumatic power for jet engine starting on ground air conditioning... and electrical power when equipped with an alternator. These rugged, completely self-contained units are also fully sound attenuated. Servicing is easily accomplished through ample access doors.

AiResearch ground support equipment can be designed to meet specific requirements or installed on standard vehicles. Your inquiries are invited.



THE GARRETT CORPORATION

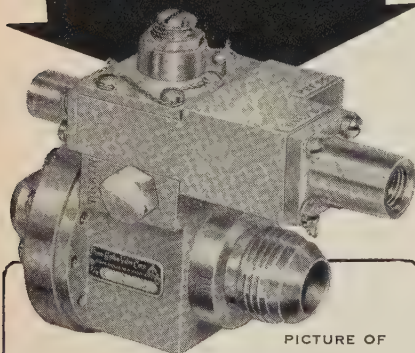
AiResearch Manufacturing Divisions

Los Angeles 45, California • Phoenix, Arizona

Systems, Packages and Components for: AIRCRAFT, MISSILE, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS

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Pneu-Hydro BALL VALVES



PICTURE OF
SERIES
360

- Zero Leakage
- Low Actuation Torque
- Straight-Through Flow
- Dependable, Long-Time Service

SPECIFICATIONS

Flow: Equivalent to tube size
Ports: Customer requirements
Temperature: Military specifications
Operating Pressures: 0 to 10,000 psi

Pneu-Hydro Ball Valves, furnished with electric, pneumatic, hydraulic or manual actuators, are available for pneumatic, hydraulic and cryogenic service.

Typical Applications: Airborne; Propulsion and Altitude Control Systems, Ground Support and Handling; Missile Fuel Loading and Hydraulic Checkout Systems.

WRITE FOR OUR BROCHURE NOW!

Let Pneu-Hydro Engineers Help Solve Your Ball Valve and Other Component Problems



Pneu-Hydro Valve Corp.

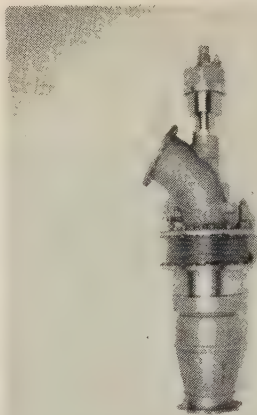
Engineers & Manufacturers of Hydraulic, Pneumatic & Cryogenic Components

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Write in No. 134 on Reader Service Card
230

PRODUCT PREVIEW

**SHAFT SEAL
is self-contained**



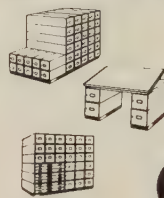
The Mechanipak mechanical seals for sealed vessel agitator shafts have been designed as self-contained, single units to permit simple, quick installation, says The Garlock Packing Co., Dept. S/A, 437 Main St., Palmyra, N.Y. The units, available for any size shaft, will prevent shaft leakage at pressures up to 3000 psi.

Temperatures in excess of 700 deg F, even in corrosive environments, will not affect the seals.

Write in No. 349 on Reader Service Card
more on page 232

Staktube®

Stacor's lifetime steel ROLL FILE SYSTEM



"Easy-file easy-find" system to keep rolled prints, plans, maps clean, safe.
24 sizes—8 lengths, 3 tube diameters.



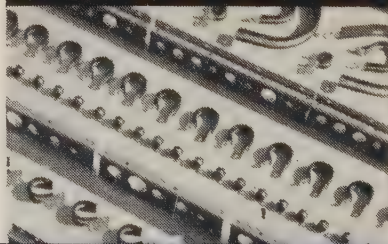
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Illustrated are but a few of the World's most complete line of Line Supports that meet or exceed all applicable specifications and/or requirements. Whatever the application—STANDARDIZE ON ADEL—the leader in completeness of line, service and reliability.

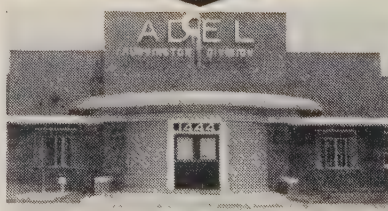
Reliability

**ADEL PRECISION
PRODUCTS**

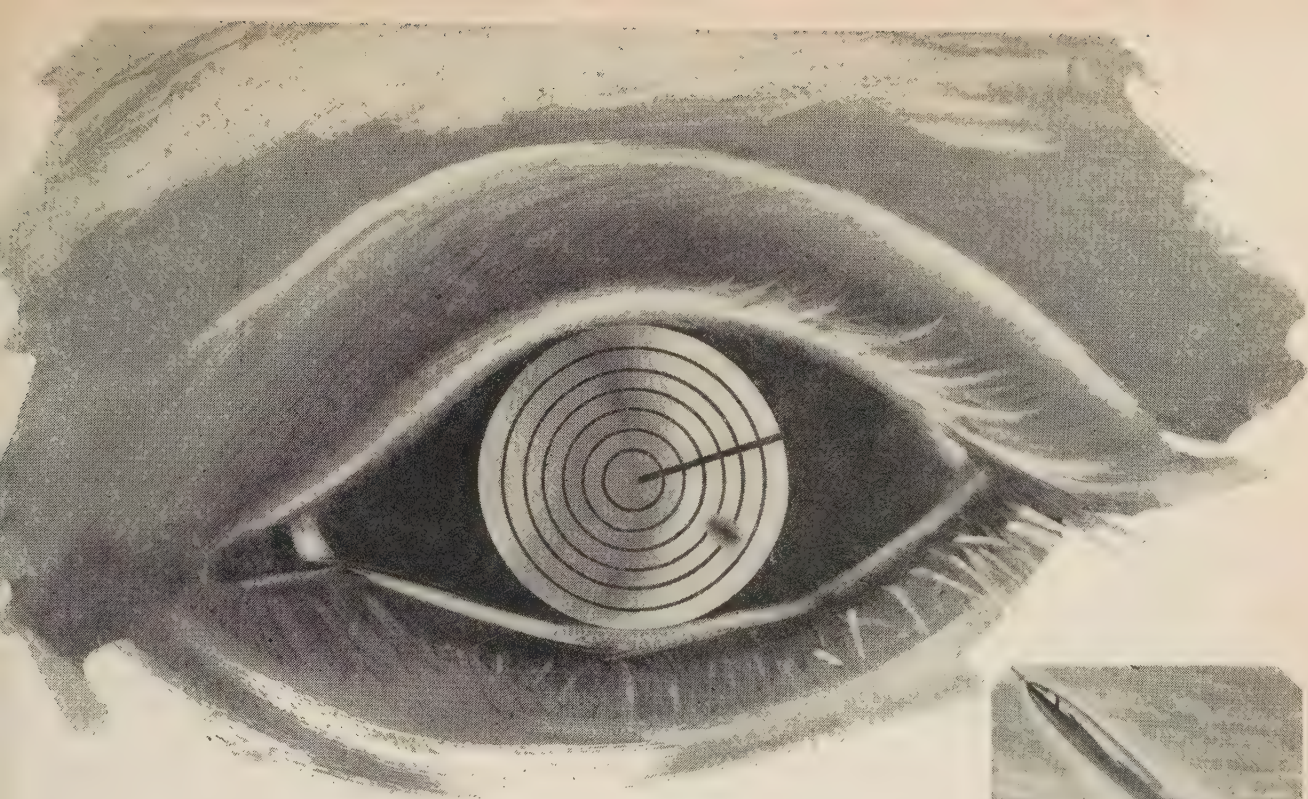
A DIVISION OF GENERAL METALS CORPORATION

SPECIFICATIONS ARE AVAILABLE TO AIRCRAFT, MISSILE AND ORIGINAL EQUIPMENT MANUFACTURERS . . . WHAT ARE YOUR REQUIREMENTS?

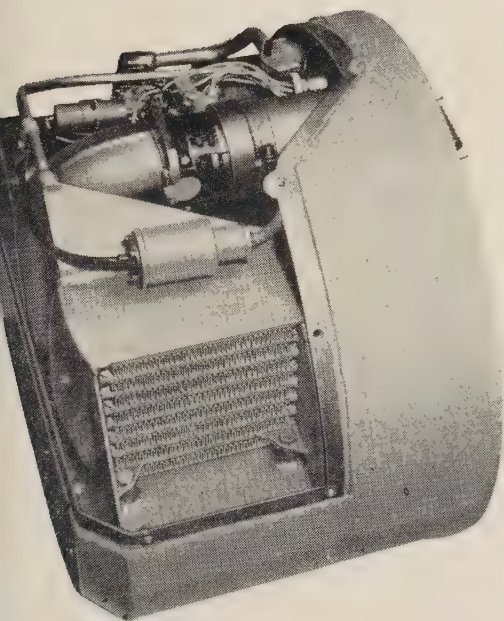
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SPACE/AERONAUTICS



When a PIP becomes a PICTURE **UAP** cools the TV tube!



A new radar tracking system, developed by Sperry Gyroscope, will pick up and track an object at a considerable distance. When the object comes within equipment range, a television camera, developed by Du Mont Laboratories, can pick up the target and show visually its identity.

Cooling and temperature control for the TV Vidicon tube and associated electronic components was assigned to a UAP mechanical refrigeration system. Components are an aluminum plate type condenser and evaporator, semi-hermetically sealed 400 cycle compressor, blower, controls and chassis. The envelope is 14" dia. x 10" long, with half the diameter reserved for the tube circuit. Capacity of the 26-pound package is 275 watts at a maximum ambient of 149° F. The UAP system was designed for shipboard application and to meet necessary MIL environmental requirements.

The pip-to-picture story demonstrates but one of UAP's many capabilities in electronic cooling. Other achievements involve liquid cooling systems, expendable refrigerant systems, and gas-to-gas heat exchanger systems. Get complete information on any of these . . . or submit your application problem today for UAP design study!

Call or write contractual engineering:

CALIFORNIA.....	1101 Chestnut St., Burbank, VI 9:5856
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CANADA.....	United Aircraft Products, Ltd., 147 Hymus Blvd., Pointe Claire, P.Q., Phone Montreal: OX 7-0810

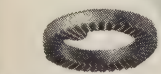


a famous family of aircraft essentials since 1929

UNITED AIRCRAFT PRODUCTS, INC.

1116 BOLANDER AVENUE, DAYTON, OHIO

Write in No. 331 on Reader Service Card at start of Product Preview Section



NEW! fast precise locking device

**cuts installation time
provides fine adjustment**

- Fine linear adjustment—within 0.001-inch
- Positive angular adjustment
- Cuts installation time drastically
- Equal to or better than older devices in torque load
- Popular sizes carried in stock

SERRATED WASHERS . . . Heart of this NAS 1193 locking device are these two serrated washers; each notch represents 0.001" linear adjustment, making this locking device one of the easiest, fastest and most accurate to work with. The mechanic has only to count the notches to make any adjustment that is needed in increments of one thousandth of an inch.

INVESTMENT CAST of Type 410 stainless, these washers have proved under test that they will not only outlast and outperform previously used washers but provide greater thread protection as well.

THIS DEVELOPMENT represents a major improvement over previous methods—its savings in installation time alone make it a "must" for aircraft and missile manufacture. If the range of sizes or type of alloys available do not serve your purpose, Arwood is prepared to cast similar locking devices to your specification.

Write today for descriptive bulletin or call your nearest Arwood representative for quick and complete information.

*Machine the simple . . .
Cast the complex*

arwood



ARWOOD PRECISION CASTING CORP.

324 West 44th Street, New York 36, New York

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& LOS ANGELES, CALIF.

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PRODUCT PREVIEW

SWITCHING COMMUTATOR features low noise

This miniature switching commutator features low noise, low torque, long life, and an angular accuracy of ten min of arc, according to Airflyte Electronics Co., Dept. S/A, 535 Ave. A, Bayonne, N.J. It is recommended for programming, data processing, telemetering, high-speed sampling, sinusoidal switches, and other uses.

The device is available in either motor-driven or hand-detented types.

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NYLON CABLE TIES are sturdy, reuseable

This cable tie can be opened, closed and re-adjusted repeatedly without damage, without special tools. Wire may be traced, added or removed from the harness quickly and easily. Designated "Lok-Strap" the design has a miniature quick-release lock which holds the band tightly and firmly around wires, says Panduit Corp., Dept. S/A, Midlothian, Ill. The tie anchor, a small plastic tab, has a mounting hole at one end and a retaining slot at the other.

For most applications one size will replace a complete range of conventional ties for wire harnesses from 1/8" to 1 3/4" in diameter it is said. For larger work, an extra long type is available for bundle diameters up to 3 1/2".

Write in No. 351 on Reader Service Card

TRANSDUCERS for linear displacement

These models of linear displacement transducers are ready for connection to the required preamplifier and input source. They include differential transformers, are encased in stainless steel shields and have a carbide tipped, spring-return contact rods, 10 foot integral cable and suitable adapters, says Industrial Div., Sanborn Co., Dept. S/A, 175 Wyman St., Waltham 54, Mass. They have a maximum stroke of ± 0.050 in. (0.100 in. total); 0.5% linearity; and operate from 5 v, 24 cps excitation.

Resolution is infinite, it is said, and a choice of 100, 25 or 10 gram contact pressures is available.

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LOX FILLER VALVE has low leakage

The 78-03 liquid oxygen filler valve, an automatic-acting type capable of mating and operating with a ground servicing unit, limits leakage to 0.02 l/min with the cap off and zero leakage with the cap on, says Arkwin Industries, Inc., Dept. S/A, 648 Main St., Westbury, N.Y. Mating opens the poppet in the valve assembly.

Operating pressure is 70 to 300 psi with liquid oxygen, and burst pressure is over 850 psi. The ten-oz valve has an operating temperature, at atmospheric pressure, of -297 deg F., and temperature range extends to $+260$ deg F.

Write in No. 353 on Reader Service Card

THRUST WASHER uses dry bearing

This thrust washer design for dry bearing operation uses a composite material consisting of a steel backing with a thin sintered porous bronze powder filled TFE fluorocarbon resin. The resin is anti-adhesive and capable of withstanding temperatures from -328° F to 536° F, says United States Gasket Co., Dept. S/A, Camden 1, N.J.

The bore diameter of thrust washers is substantially larger, about 1/16 in., than the journal diameter in which they are mounted. A dowel hole is provided in each washer to receive a loose fitting dowel which is satisfactory for journals rotating in one direction.

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more on page 234

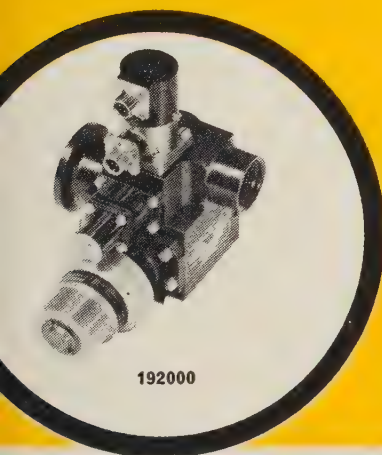
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SPACE/AERONAUTICS

Smaller, lighter, wider range

PNEUMATIC MISSILE REGULATORS

are three pneumatic regulators from among the
eds of sophisticated missile components developed
anufactured by Wallace O. Leonard, Inc. during
ast ten years. Accommodating air, nitrogen or
n, these regulators are smaller and lighter than units

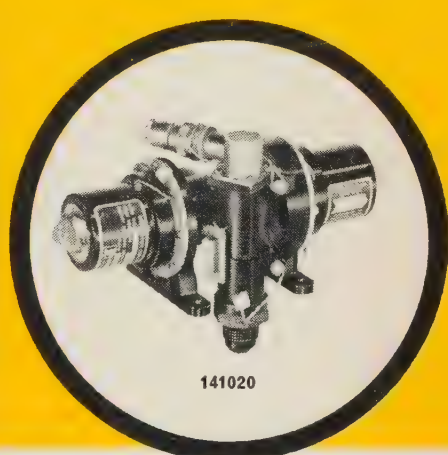
of comparable capabilities, have a wide range of inlets
and flows, have no buzz, and are practically insensitive
to vibration and shock. Note specific performance data
and parameters. These Leonard regulators are now in use
on many major missile systems and in ground support.



192000



193000



141020

DESCRIPTION

MISSILE FUEL AND OXIDIZER TANK PRESSURIZATION. Maintains Constant Pressure During Firing Cycle.

Available with Solenoid Shut-Off and Position Indicators

Air, Nitrogen or Helium

Operating Data (Typical)

13-25 PSIG ± 5 PSIG

3000 to 600 PSIG

4500 PSIG

7500 PSIG

5-40 lbs./min.

Porting

10 cu. in./min. (when shut off)
Zero

-65° to +165° F

MIL-E-5272, Proc. 1

20 G's (1 plane)

3.5 lbs.

PNEUMATIC STEERING NOZZLE SUPPLY Provides Accurately Controlled Gas Pressure to Nozzle for Missile Positioning and Stability Operations.

Integral Relief Valve
Solenoid Actuation Optional

Air, Nitrogen or Helium

300-400 ± 5 PSIG

3000 to 600 PSIG

4500 PSIG

7500 PSIG

6-24 lbs./min.

10 cu. in./min.

10 cu. in./min.

Zero

-65° to +165° F

MIL-E-5272, Proc. 1

20 G's (1 plane)

3.7 lbs.

INSTRUMENT AIR BEARING SUPPLY Provides Precisely Regulated Gas Pressure for Guidance Components. Maintains Regulation Level and Control Over Wide Range of Inlet Conditions and Environments.

Available with Solenoid Shut-Off, Relief Features, etc.

Air, Nitrogen or Helium

30 to 55 ± 2 PSIG

3000 to 200 PSIG

4500 PSIG

7500 PSIG

8 to 20 SCFM

2 cu. in./min.

1 cu. in./min.

1 cc/hr.

-65° to +165° F

MIL-E-5272, Proc. 1

20 G's (1 plane)

1.45 lbs.

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design, engineering, production and testing. Its skilled craftsmen and ad-
vanced technical personnel have built an enviable reputation for
high quality products ranging from simple pressure switches to complex
hydraulic systems for missile guidance, control and ground support. Your
company is invited. For consultation and information please write to:

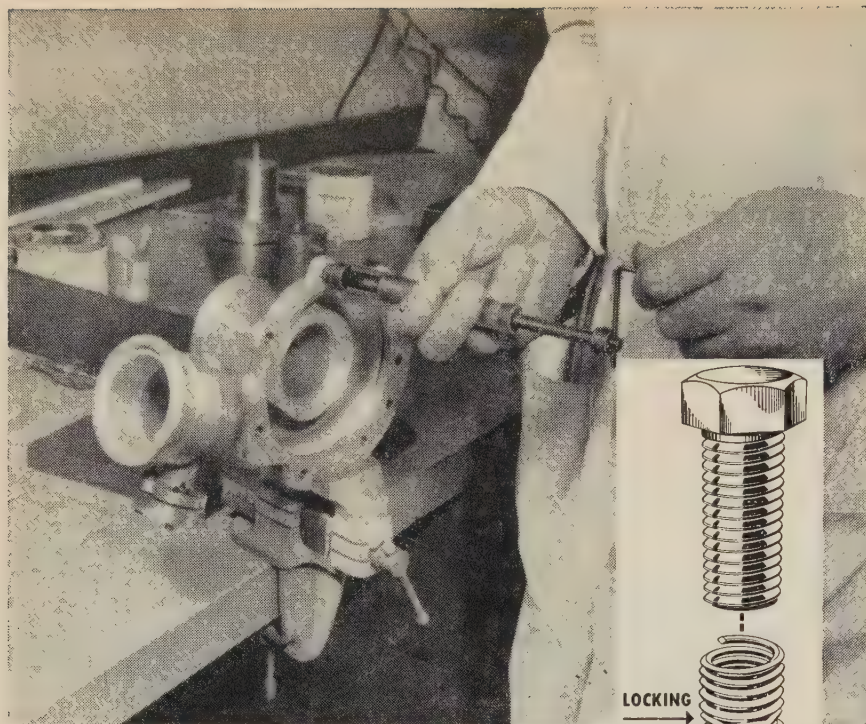
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Heli-Coil® Stainless Steel Screw-Lock Insert is easily wound into tapped hole in lightweight aluminum housing. Spring tension of the locking coil retains screw securely, meets military specifications for locking torque and vibration.

How Carrier Corporation Saves 40% in weight • 30% in assembly time ...with **HELI-COIL®** SCREW-LOCK INSERTS*

Use of aluminum lightens Carrier refrigeration system in Douglas DC-8 Jetliner

To reduce weight in the refrigeration system designed for air conditioning the giant Douglas DC-8 Jetliner, Carrier engineers used aluminum alloy compressor castings. To obtain maximum performance and reliability of threaded connections exposed to heat and vibration encountered at 600 mph, they selected the **Heli-Coil** stainless steel wire thread, *internal locking* Screw-LOCK Insert.

The results: design simplified, boss areas minimized, weight re-

duced as much as 40%, lock nuts and lock wiring eliminated. Now one man assembles the entire unit in 30% less time than before ...and danger of thread failure and screw loosening has ended!

Manufacturers in every field are relying on one-piece, stainless steel **Heli-Coil** Screw-LOCK Inserts to meet torque and vibration specs...protect threads against wear, stripping, galling and corrosion...save costs, space and weight.

*Patented



HELI-COIL CORPORATION
DANBURY, CONNECTICUT

HELI-COIL CORPORATION 101 Shelter Rock Lane, Danbury, Connecticut

I'd like more information on *Heli-Coil* Screw-LOCK Inserts

NAME _____ TITLE _____

FIRM _____

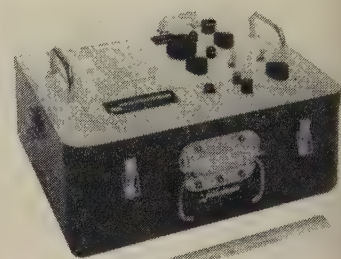
ADDRESS _____

CITY _____ ZONE _____ STATE _____

IN CANADA: Armstrong Beverley Engineering Ltd., 6975 Jeanne Nanse St., Montreal 15, Que.

Write in No. 140 on Reader Service Card at start of Product Preview Section

RAMP TESTER is portable

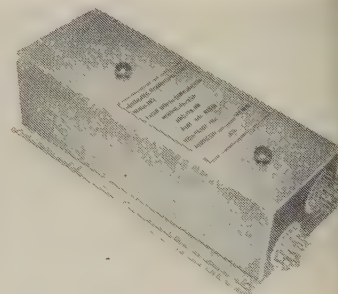


The self-contained, portable, 35-lb ATC Transponder Ramp Tester can perform a confidence level test from ramp or shop by means of optional radiation or umbilical methods, says Packard Bell Electronics Corp., Dept. S/A, 12333 W. Olympic Blvd., Los Angeles 64, Calif. Four front-panel controlled tests are possible: go no-go, for proper frequency power and code output; frequency-power; identity; and self-test, for complete operating characteristics on a closed loop go no-go basis.

The ATC tester's decoder circuit can process 64 combinations of a coded pulse train. Radiation tests can be performed from ten to 50 ft into a -75 dbm receiver. The antenna, a vertically-polarized directional type, is permanently attached.

Write in No. 355 on Reader Service Card

TIMER has sequence action



This timer is used to energize a series of power supplies in succession to that, voltage is developed in a predetermined order. Except for the first, each power supply is turned on approximately 7 seconds successively, says Eagle Signal Corp., Dept. S/A, Moline, Ill. Known as the HYS89, it has 26 load switches which close in pairs.

It has a motor cutoff switch operative after 90 seconds. The reset takes 5 to 10 seconds. It operates from 115 V 400 cycle for the motor and 20 vdc for the clutch. Operable at 5G's, 300 cycle vibration. Operating temperature range, -55 deg C to +85 deg C. It measures about 4 1/2 x 2 1/2 x 8 1/2 and weighs 60 oz.

Write in No. 356 on Reader Service Card
more on page 230

NEW VICKERS® Packaged Valve

Assembly accelerates – decelerates
Thor Missile Erector smoothly
without ratcheting.



Operating Pressure 3400 P.S.I.
Proof Pressure 4500 P.S.I.
Burst Pressure 7500 P.S.I.
Temperature Operating Range -65°F to +150°F
Filtration Nominal 10 Micron

Smooth control of the Thor erecting cylinder is accomplished by a new Vickers' packaged valve assembly. This assembly provides regulated acceleration-deceleration throughout the erecting cycle without compounding structural vibrations. Despite varying external loads and temperatures, firm positive control is maintained as the missile's center of gravity passes over the pivot point.

This "system engineered" valve is another example of the special ability of the Vickers Marine and Ordnance Department to solve difficult ground support problems. An integrated package, this new valve consists of a metering-type, modulating flow control that is pressure compensated for a fixed pressure differential. An integral, motor-actuated, 4-way directional control regulates starts and stops in mid-cycle.

Now in production, this valve can be used to control a broad range of accelerations, decelerations and overrunning loads merely by varying combinations of orifice sizes and spool configurations. Horsepower input can be adjusted to meet onsite power availability. Valve output can be controlled electrically, mechanically or hydraulically. Mounting flexibility permits valve installation directly on the hydraulic cylinder.

All units are factory pre-tested, interchangeable and require no external lines except to pump and tank. They are built to meet the most demanding reliability requirements.

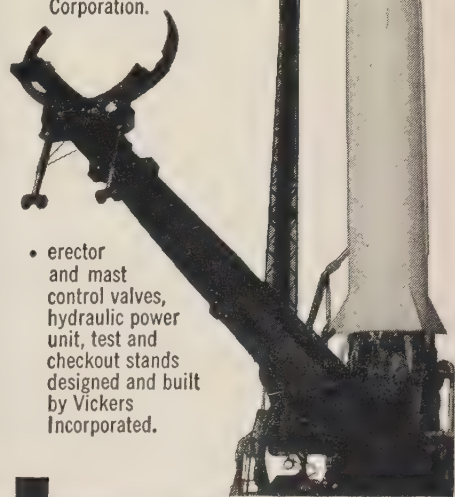
this valve offers a solution to your problems, call Waterbury, Connecticut, PLaza 3684 (TWX: WBY 160) for more complete information. Write for a free copy of bulletin 5303 "Vickers Oil Hydraulics for Missile Systems."

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
Marine and Ordnance Department
WATERBURY 20, CONNECTICUT

DISTRICT SALES OFFICES: DETROIT, MICH. • EL SEGUNDO, CALIF. • BERKELEY, CALIF. • WASHINGTON, D. C. • WATERBURY, CONN.

THOR missile on launch base...

- complete system designed and developed by Douglas Aircraft Company, Inc.
- transporter-erector, launching base and power trailer designed and built by Food Machinery and Chemical Corporation.



- erector and mast control valves, hydraulic power unit, test and checkout stands designed and built by Vickers Incorporated.

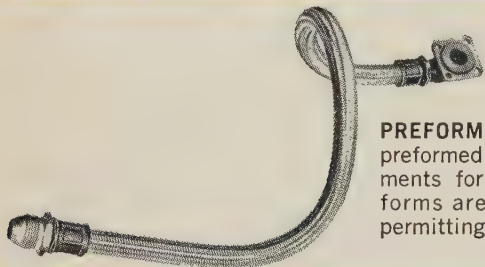
**Hydraulic Products
for Marine
and Ground Defense
Applications**

Write in No. 141 on Reader Service Card at start of Product Preview Section

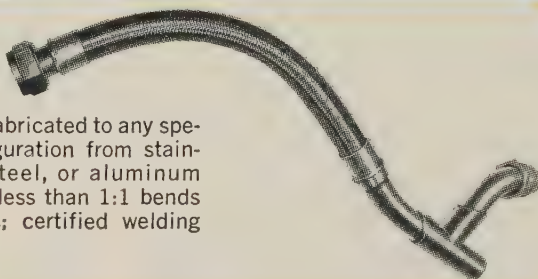
Fluoroflex®-T (Teflon®)

PLUMBING

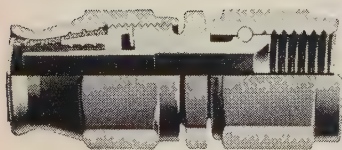
engineered for SAFETY, RELIABILITY



PREFORMED CONFIGURATIONS. Factory preformed to meet specific routing requirements for almost any configuration. Pre-forms are stress relieved at the bends, permitting tighter bend radii than free hose.

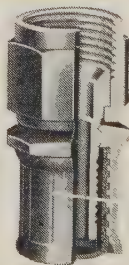


SPECIAL FITTINGS. Fabricated to any specified angle or configuration from stainless steel, carbon steel, or aluminum alloy. Compound and less than 1:1 bends to aircraft tolerances; certified welding and brazing.



SEAL-LOCK FIELD ATTACHABLE, REUSABLE FITTING. Designed for maximum flexibility in teststand and mockup work. Dynamic sealing and triple-locking actions make assemblies leak-proof and blow-off proof. Sizes -3 through -24Z qualified to MIL-H-25579.

SWAGED FIELD ATTACHABLE, PERMANENT FITTINGS. Designed for maximum reliability. Resistoflex swaged fittings have proven their dependability in more than 3 million assemblies. Available in all standard sizes and a variety of configurations including elbows and special attachments.



©Fluoroflex is a Resistoflex trademark, reg., U.S. pat. off.
©Teflon is DuPont's trademark for TFE fluorocarbon resins.

Originators of high temperature fluorocarbon hose assemblies

Resistoflex

CORPORATION

Dept. 272

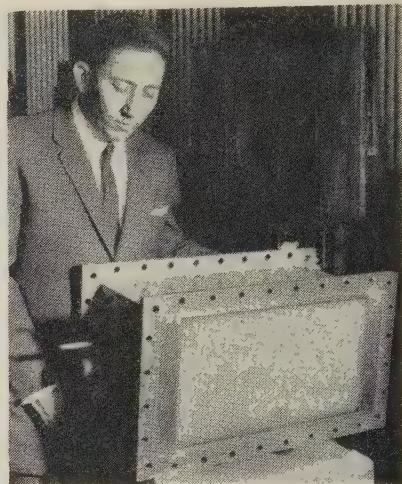
Offices in principal cities

Roseland, New Jersey • Western Plant: Anaheim, Calif. • Southwestern Plant: Dallas, Texas.

Write in No. 142 on Reader Service Card at start of Product Preview Section

PRODUCT PREVIEW

WAVEGUIDE WINDOW for multi-megawatt uses

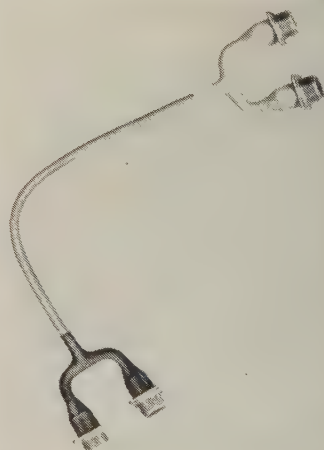


This window, primarily intended for use with the WR-2100 waveguide, provides excellent RF continuity and a low SWR of 1.03 over a 10 per cent band, says I-T-E Circuit Breaker Co., Dept. S/A, 1900 Hamilton St., Philadelphia, Pa.

The window achieves high-power-handling capabilities by use of special cross-linked polystyrene as a mechanical barrier. A matching iris is provided to reflect discontinuous energy.

Write in No. 357 on Reader Service Card

MOLDED HARNESSES for rugged environments



Maximum protection against specific environmental hazards over a broad temperature range has been provided by these molded harnesses and special electric cable assemblies, says Revere Corp. of America, Dept. S/A, Wallingford, Conn. Constructions are engineered to provide excellent resistance to corona, abrasion, tear, fuel, oil, and solvents, and they are moisture and fungus proof.

Harnesses can be made for -120 to +500 deg F continuous use, or to +600 deg F intermittent use.

Write in No. 358 on Reader Service Card
more on page 238

VOICE OF THE DEEP



Neptune, the mythological ruler of the deep, had all the waters of the earth as his domain. Triton, his son, was assigned the vital task of communicating his father's commands to submarines in all parts of the ocean.

The U. S. Navy has need of a counterpart for Triton. RCA is now assisting in this role through development of a communication link to our

new nuclear powered Polaris-carrying submarines, anywhere on the seven seas.

RCA, in addition to its Polaris developments, is also working on many new Undersea Warfare systems such as detection, classification and destruction of enemy submarines as well as coordination of our friendly air, surface, and subsurface effort.



RADIO CORPORATION of AMERICA

DEFENSE ELECTRONIC PRODUCTS

CAMDEN, NEW JERSEY

METAL TUBING is inflatable

An interesting metal, seamless tubing that can be shipped in ribbon form and inflated at the point of use holds promise of important contributions to the power distribution, communications and rocket and missile fields, among others, says Wolverine Tube Div., Calumet & Hecla, Inc., Dept. S/A, 17200 Southfield Rd., Allen Park, Mich. For example, Strubing is said to lend itself to the manufacture of light-wall, large diameter, seamless rocket and missile bodies, and smaller diameter tubing may serve as fuel line tubing required to handle highly-corrosive liquids.

Strubing can be made and shipped economically and it is said to open the thin-wall tubing field to materials and thicknesses presently available only at a prohibitive cost, if at all. The tubing size range covers those smaller than pencil lead to those large enough for a man to walk through. Wall thicknesses range from the thinness of household metal foil to the thickness of conventional pipe. Strubing has been inflated by means of hydraulic pressure, air pressure and mechanical means.

Write in No. 359 on Reader Service Card

INSTRUMENT SWITCH has dual concentric shafts

This miniature, instrument-quality rotary switch with dual concentric shafts is for instruments, computers, and other commercial and military equipment. Eight switch decks may be ganged, with the inner shaft controlling up to 4 of the 8 decks, says Shallcross Mfg. Co., Dept. S/A, Selma, N.C. Two separate and entirely different switching actions on the two concentric shafts may be combined.

One shaft may control one or several 1-pole decks; the other, 4-pole decks. One set of decks may be shorting, the other non-shorting. One set of docks may have 11¼° indexing, the other 22½° or 30°. The ⅜ in diameter inner shaft may also be used to operate rheostats, potentiometers, or condensers.

Write in No. 360 on Reader Service Card

LAMINATE for high temperatures

Thermala No. 1255, a black laminating resin, was developed for production of high strength laminates for continuous use at temperatures of 400 deg F to 600 deg F. Standard wet lay-up techniques are employed in using the new material, says Hastings Plastics, Inc., Dept. S/A, 1551 12th St., Santa Monica, Calif.

Among physical properties are: Edgewise compressive strength, ultimate psi 59,000; flexural strength psi at 77 deg F 76,000, and at 500 deg F (after heat aging 100 hrs. at 500 F 27,000; tensile strength psi at 77 deg F 51,000, and at 500 deg F (after heat aging 100 hrs. at 500 deg F) 21,000. Heat distortion point 500 deg F.

Write in No. 361 on Reader Service Card

AMPLIFIER for in-flight use

An airborne amplifier for in-flight strain gage and accelerometer signal amplification is sub-miniature and designed for use with piezoelectric accelerometers, according to Southwestern Industrial Electronics Co., Dept. S/A, P.O. Box 13058, Houston 19, Texas. It has a high-impedance (over 500 megohms) grounded input and less than 20 k grounded output, it is said.

Gain is continuously variable from 10 to 100 at up to 60 mv (rms) input. Bandwidth is 5 cps to 10 kc, and gain stability and linearity are 5 per cent and 1 per cent. The AC-1 can operate in environments of -20° to +100° C temperature, up to 100,000 ft. altitude and 10g, 2 kc vibration. Weight is 4 oz.

Write in No. 362 on Reader Service Card

more on page 340

Write in No. 145 on Reader Service Card →
SPACE/AERONAUTICS



CHARACTERISTICS

ANALYSIS

- 1 Stainless Steel Ball and Race
- 2 Chrome Alloy Steel Ball and Race
- 3 Bronze Race and Chrome Steel Ball

RECOMMENDED USE

- { For types operating under high temperature (800-1200 degrees F.).
- { For types operating under high radial ultimate loads (3000-893,000 lbs.).
- { For types operating under normal loads with minimum friction requirements.

Thousands in use. Backed by years of service life. Wide variety of Plain Types in bore sizes 3/16" to 6" Dia. Rod end types in similar size range with externally or internally threaded shanks. Our Engineers welcome an opportunity of studying individual requirements and prescribing a type or types which will serve under your demanding conditions. Southwest can design special types to fit individual specifications. As a result of thorough study of different operating conditions, various steel alloys have been used to meet specific needs. Write for Engineering Manual No. 551. Address Dept. S/A 60.

SOUTHWEST PRODUCTS CO.

1705 SO. MOUNTAIN AVE., MONROVIA, CALIFORNIA

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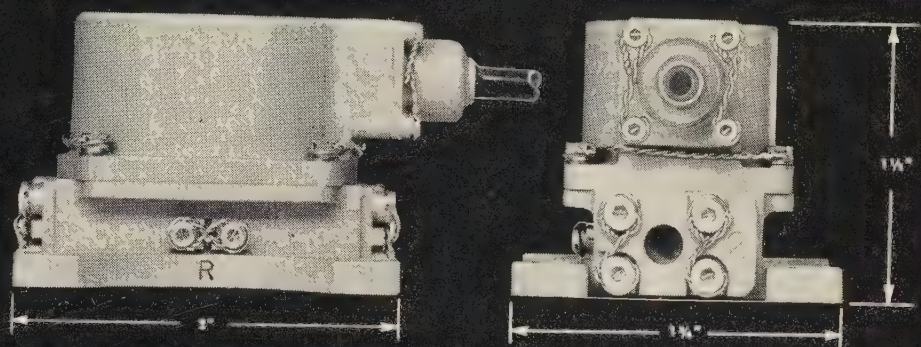
NEW
0.32 lb (TOTAL WEIGHT)

MECHANICAL FEEDBACK

DRY MOTOR

LOW FLOW CONTROL

SERVOVALVE



"INDUSTRY STANDARD MOUNTING DETAILS"

For critical applications where outstanding performance must be achieved with a minimum of weight, Moog offers the Series 30 Servovalve. These valves utilize the proven first stage of the standard Series 31 and 32 Moog valves, and are now available with rated flows to 7 cfs at 1000 psi valve drop.

WRITE FOR PRODUCT BULLETIN 113

from **MOOG** :

MOOG SERVOCONTROLS, INC.

PRONER AIRPORT, EAST AURORA, NEW YORK



This unique, flush-mounted oxygen outlet features a retractable, self-purging dust cap that never needs to be removed or pushed aside. It's easy to operate, too — just a soft push to insert and a quick twist to remove. Lightweight — (under 1 oz.) — this outlet is functionally designed — only one moving part. Here is the same principle that has been proved in thousands of hospital pipeline installations — now adapted for aircraft use!

For complete data and free engineering aid from specialists in oxygen piping systems, please write to Aviation Dept.



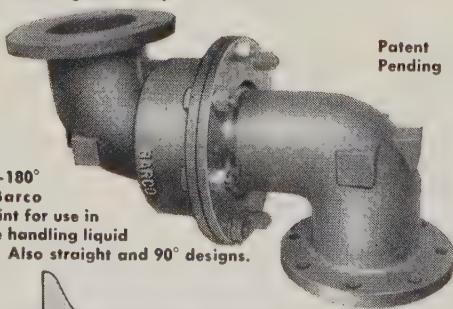
Write in No. 131 on Reader Service Card

BARCO

Flexible Joints for Handling Liquid Oxygen and other missile fuels

BARCO has the *specially designed* flexible joint which has passed the official "Qualification Test":

- Used in piping on fueling lines handling liquid oxygen, JP4 and JP5 fuel, white and red fuming nitric acid, and other chemicals.
- Provides swivel motion to allow for thermal expansion and contraction.
- High corrosion resistance. Other special designs available. For temperatures from -320°F. to $+1,000^{\circ}\text{F.}$, and higher. Also joints for gas and hydraulic service.



(Right) 6" — 180° flanged Barco Flexible Joint for use in fueling line handling liquid propellant. Also straight and 90° designs.

AIRCRAFT DIVISION

BARCO Serving Industry Since 1908
MANUFACTURING CO., 575B Hough St., Barrington, Illinois

Write in No. 146 on Reader Service Card

RF COAX for high temperatures

Continuous operation at 1000 deg F has been reported for this RF coaxial cable designed primarily for missile, aircraft, space craft and nuclear applications. The cable system, which consists of a flexible, special metal-alloy jacketed RF cable with Series N, C or SC connector terminations, is resistant to radiation, shock, vibration, and moisture, and it is altitude insensitive, says Amphenol-Borg Electronics Corp., Dept. S/A, S. Harlem Ave. & 63rd St. Chicago 38, Ill.

Inner and outer conductors of the cable are coated, oxygen-free, high-conductivity copper wire. The system is said to be so flexible that it can be bent 30,000 times without dielectric deterioration. Bend diameter is ten times the diameter of the cable. Nominal impedance is 50 ohms and maximum operating voltage is 1000 V rms.

Write in No. 363 on Reader Service Card

FLAT RING SEAL for reservoir

This flat ring seal fabricated from teflon, approximately 12 in OD, was machined from special, high-density TFE resin. It replaces conventional materials, it is said, which demonstrated "drag", shortens reservoir life to an undesirable point. Because of TFE's extremely low coefficient of friction and non-hesive characteristic, fluid friction was reduced by 50 per cent to a tolerable level, according to Tri-Point Plastics, Inc., Dept. S/A, 175 I.U. Willets Rd., Albertson, L.I., N.Y. Ready removal of ring during maintenance is possible due to the plastic's "non-stick" characteristic.

The ring is used as a cap seal for a reservoir, in a system which operates at 3000 psi, at temperatures of about 275 deg F. The TFE ring seal is exposed to 50 psi pressure, with fluid requirements specified in MIL H-5606.

Write in No. 364 on Reader Service Card

GAS FILTER pressures 1000 psi

This pressure filter is capable of operating at pressures to 1000 psi and temperatures to 275 F. It is designated the P-192 series and is designed for pneumatic and hydraulic systems to provide effective filtration for such fluids as lubricating oils, ethylene glycol mixtures, hydraulic fluids (including mineral oil base, silicate esters, and diester oil base), fuel and oils, plus air and gases, says Purolator Products, Dept. S/A, Rahway, N.J.

Any model can be adapted for filtration of many other types of fluids by changing to the proper gasket material. Design permits use of replaceable paper elements, wire mesh, or varied-spacing metal-edge filtering media with degrees of filtration ranging from 2 to 25 microns.

Write in No. 365 on Reader Service Card

MICROPHOTOMETER measures light intensity

The Photomultiplier Microphotometer is designed for precise measurement and comparison of light intensities as low as 0.4 micro-microlumens. The instrument permits measurement of intensity ratios from 100 per cent to 0.001 per cent and densities from 0 to 5, says American Instrument Co., Dept. S/A, 8030 Georgia Ave, Silver Spring, Md.

Normally used in conjunction with other instruments to form an operational system for research in specific analytical fields such as fluorescence, light-scattering, phosphorescence, etc., the instrument can be used to measure light intensities at selected wavelengths transmitted through microscopes, polariscope, spectroscopes or the measurement of stellar light transmitted through telescopes.

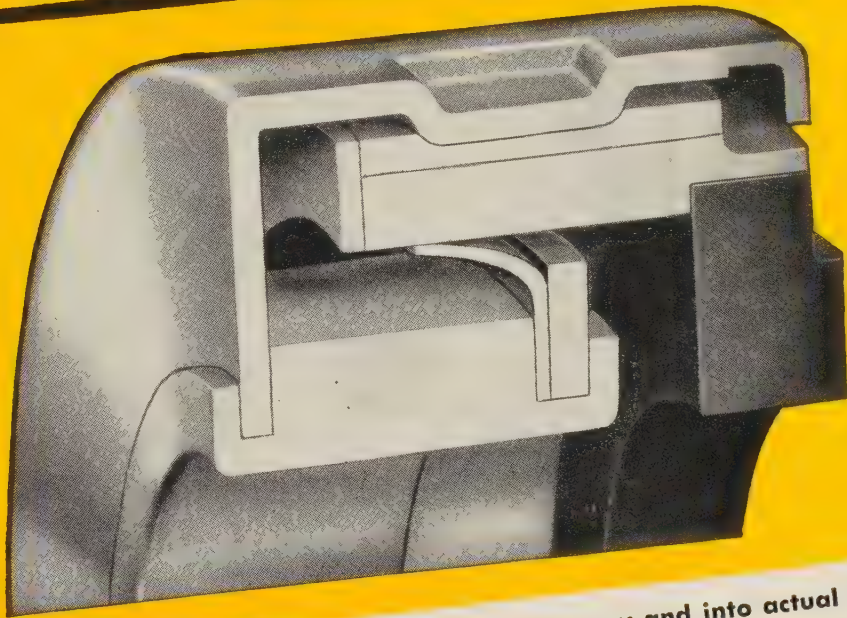
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more on page 244

Write in No. 147 on Reader Service Card

SPACE/AERONAUTICS

NEW Only Gits Met-L-Seal* Seals at -65° to $+850^{\circ}$ F.



Now beyond the Research-Development Laboratory and into actual production — nothing like it on the market! Consider these exclusive design advantages, producing a built-in "missile reliability":

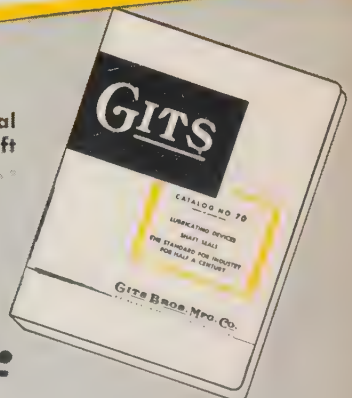
- 1 Hydraulic balance producing optimum sealing under both static and dynamic conditions — not always available in other all-metal seal designs.
- 2 Functions at temperatures, pressures and speeds in excess of capabilities of currently used organic materials — in minimum space required by aircraft-missile applications.
- 3 No internal fatigue. All components, except seal face, are made of various high-temperature alloy steels, each with the optimum combination of properties necessary to its function. (Exclusive Gits design makes Met-L-Seal operable at temperatures even higher than 850° , limited only by metallurgical progress in high-temperature alloy steels.) Positive guarantee against sudden complete operational failure and other drawbacks of synthetic-elastomer seals in extreme operating conditions.
- 4 No "shelf life" problems. No "cure-date" limitations as are necessary with synthetic-elastomer seals.

Send for new "Advance Catalog" or submit your seal problem to the experienced engineers of the Gits Aircraft and Missile Seal Division.

GITS BROS. MFG. Co.

Aircraft and Missile Seal Division
1866 S. Kilbourn Ave. • Chicago 23, Ill.

Specialists in Lubricating Devices and Shaft Seals for Almost Half-A-Century

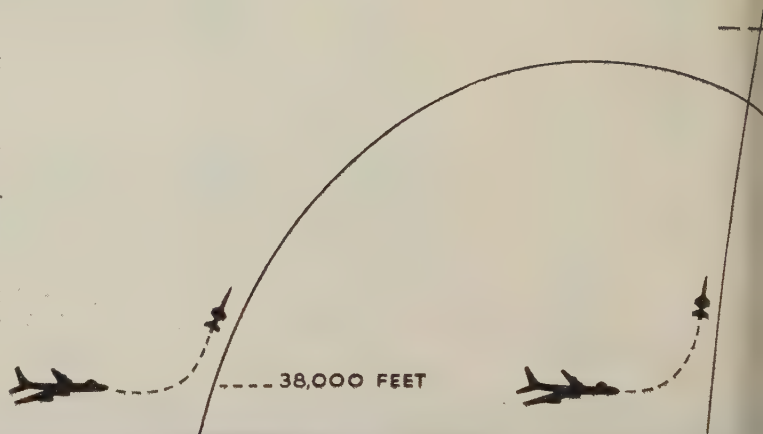


ss steel
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**Honeywell is developing an
advanced self-adaptive flight
control system for test in manned
space research vehicles**

Honeywell, under sponsorship of the Wright Air Development Center's Flight Control Laboratory, is currently developing an advanced Self-Adaptive Flight Control System for future hypersonic weapons systems. This system is being designed to perform the critical task of automatic control and stabilization throughout the entire flight profile, including integration of aero-dynamic and reaction controls. It is typical of those systems to be evaluated for future flight test in the X-15.



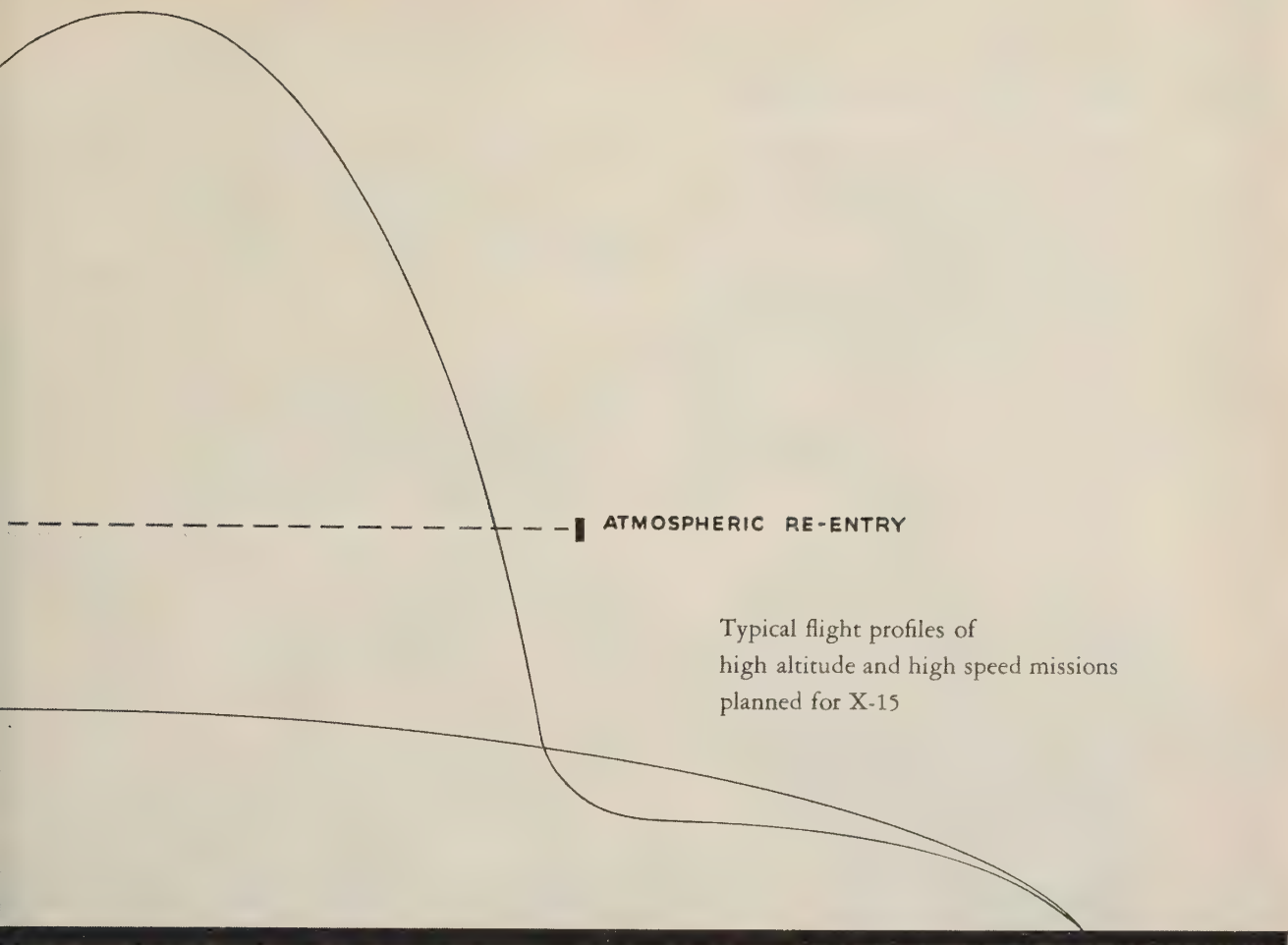
FROM SEA LEVEL

The Honeywell Self-Adaptive Autopilot

**is designed to deliver optimum performance
for every type of flight vehicle**

The simplest, most reliable automatic flight control system yet designed, the Honeywell Self-Adaptive Autopilot operates independently of air data information and complex gain scheduling. Adjusting itself in response to its own performance, it is unaffected by changes in aero-dynamic characteristics.

The advantages of this highly versatile system relate directly to stringent military requirements and are detailed on the opposite page.



Typical flight profiles of
high altitude and high speed missions
planned for X-15

TO SPACE

Simplicity—Needs no air data information for gain scheduling—is not significantly affected by design modifications in aircraft, asymmetric loading or center of gravity changes—easily mechanized and needs little tailoring to specific vehicles—is 45% smaller and lighter—requires 50% less power.

Reliability—Provides major reduction in required components, sub-assemblies and wiring—uses solid state amplifiers and switching logics.

Economy—Assures significant cost reductions through low initial cost of design and development, and simplified logistics, training and maintenance.

Versatility—The Honeywell Self-Adaptive Autopilot System can be quickly adapted without major modifications to air vehicles of all types—business aircraft, helicopters, drones, supersonic fighters and bombers, missiles and the latest hypersonic research vehicles. Having previously gone through highly successful tests in the F94C, the system is now undergoing flight tests in both the supersonic F101A and "light-twin" Cessna 310 aircraft—impressive evidence of its wide range of adaptability. To learn about fitting it into your plans, call or write Honeywell Aero, Dept. 671, 2600 Ridgway Road, Minneapolis, Minnesota.

Honeywell



Military Products Group

Write in No. 148 on Reader Service Card at start of Product Preview Section

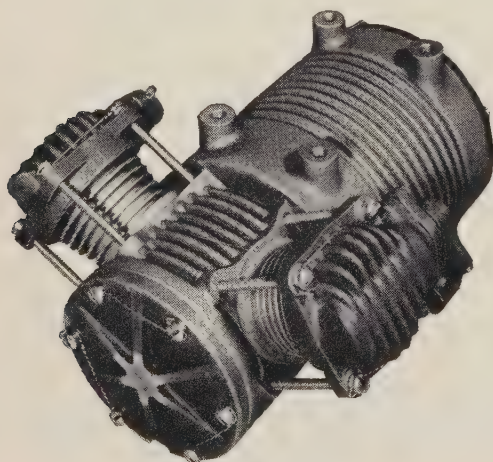
NEW SERIES HERMETICALLY SEALED

REFRIGERANT MOTOR-COMPRESSORS

... are light weight, small in size and can operate in any attitude due to an oil mist lubrication system. Units operate in high ambient temperatures and life expectancy ranges up to 5,000 hours.

Model 101-147 is only one of a series of units designed and developed by Great Lakes to satisfy special requirements for electronic cooling systems. All compressors ranging in size from $\frac{1}{6}$ to $6\frac{1}{2}$ hp are designed to meet MIL E 5400 and MIL M 7969 A Specs.

Let us show you how you can save time and money by incorporating existing units in your design plans at an early stage.



SPECIFICATIONS:

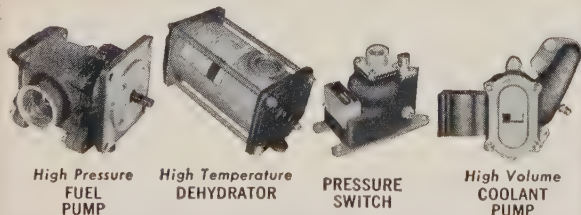
CAPACITY ... ranges from 147 to 17,600 watts per hr. (500 to 60,000 BTU per hr.)

REFRIGERANTS ... 11, 12, 22, and 114.

MOTORS ... 3 phase 400 C.P.S.

WEIGHT ... commensurate with Aircraft Practice.

Some of the complete line of products designed and manufactured at Great Lakes



High Pressure
FUEL
PUMP

High Temperature
DEHYDRATOR

PRESSURE
SWITCH

High Volume
COOLANT
PUMP

Write today, for complete information on Great Lakes PNEUMATIC-FUEL-HYDRAULIC Components. An experienced Sales Engineer is available to discuss your requirements.

GREAT LAKES

MANUFACTURING CORPORATION

4223 Monticello Boulevard • Cleveland 21, Ohio
Write in No. 149 on Reader Service Card

HYDRAULIC VALVE has fast action

A hydraulic valve that can be opened or closed with three-thousandths of a second for applications in rocket launching, fire-fighting, and nuclear reactors is now being produced by the Bendix-Pacific Div., Dept. S/A, No. Hollywood, Calif.

The valve differs in appearance from the normal hydraulic valve in its diameter, which is no larger than the pipeline or piston on which it is mounted. There is no stem-and-wheel branching up from the valve. It is tubular, and its "mouth diameter" can be designed from $\frac{1}{2}$ in to 36 in or more.

Write in No. 367 on Reader Service Card

MICRON FILTER has pressure relief valve

This 10 micron fuel filter, No. 65022, equipped with a disposable cellulose element, removes particles larger than 10 microns in its standard design but may be modified to filter particles ranging in size from 5 to 75 microns, says Aero Supply Mfg. Co., Inc., Dept. S/A, Corry, Pa. The lightweight unit is 4.9 lbs and is equipped with three sensing ports per AND 10050-4. It has a by-pass valve which goes into action should abnormal contamination occur.

Designers say it will handle 69,000 gallons before the relief valve opens, based on 8 grams of contamination per thousand gallons of fuel.

Write in No. 368 on Reader Service Card

STEPPING SWITCH is highly durable

This 11-point spring-driven stepping switch, type 211, will accommodate twelve 11-pt levels and up to four 33-point levels. It will operate for approximately 100 million steps between adjustments, according to C. P. Clare & Co., Dept. S/A, 3101 Pratt Blvd., Chicago 45, Ill. Production quantities will be available in the late Fall it was said.

Its durability is said to be owing to elimination of pawl bearings and the addition of heavier duty armature bearings and arms.

Write in No. 369 on Reader Service Card

THERMOCOUPLE HARNESS for special use

This large flexible harness will provide individual and averaged readings from eight dual junction thermocouples. Furnished in various types of materials it is capable of operation under maximum temperatures of 800, 1200, or 1600° F, according to Harco Laboratories, Inc., Dept. S/A, 77 Olive St., New Haven, Conn. It is said to be unaffected by a wide vibration range.

The small unit has four integral thermocouples. Output is the arithmetical average of the temperatures as seen by the thermocouples.

Write in No. 370 on Reader Service Card

ACCELEROMETER is small and rugged

This accelerometer with a potentiometric output is 1x1.5x1.4 in and weighs less than 4 ozs. It is said to have a low natural frequency with relative high resolution. Units are available in ranges from 5 G to 50 G and natural frequencies from 15 to 48 cps, says Giannini Controls Corp., Dept. S/A, 918 E. Green St., Pasadena, Calif. Hermetic sealing and design characteristics make model 24124 rugged.

Units withstand 50 G, 11 millisecond shock and 50 G steady-state acceleration in any axis without structural damage. Operating temperature range is -54 deg C to 71 deg C with an accuracy band of ± 5 per cent.

Write in No. 371 on Reader Service Card

more on page 247
Write in No. 150 on Reader Service Card →
SPACE/AERONAUTICS

The
Avco-Everett Research Laboratory
announces

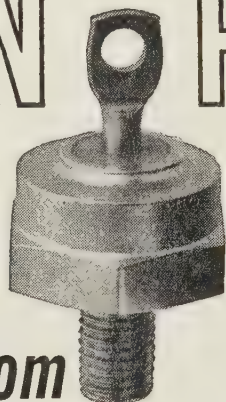
it is expanding its activities
to explore and bring to engineering fruition,
new concepts in Satellite and
Space Vehicle Design,
Electric Propulsion for Space Vehicles,
and Generation of Electricity
for both Ground Station and Space Application
through MHD.

IF THIS OPPORTUNITY
INTERESTS YOU, WRITE:

DR. ARTHUR KANTROWITZ, DIRECTOR
AVCO-EVERETT RESEARCH LABORATORY
2385 REVERE BEACH PARKWAY
EVERETT 49, MASSACHUSETTS

Announcing...

SILICON RECTIFIERS



from

DELCO RADIO

High Quality
High Performance
Extreme Reliability

From the leading manufacturer of power transistors, new Silicon Power Rectifiers to meet your most exacting requirements. Even under conditions of extreme temperatures, humidity and mechanical shock, these diffused junction rectifiers continue to function at maximum capacity! Thoroughly dependable, completely reliable—new Delco Rectifiers are an important addition to Delco Radio's high quality semiconductor line.

**Conservatively rated at 40 and 22 amperes
for continuous duty up to case temperatures of 150°C.**

		TYPE	AVG. DC CURRENT	PIV	NORMAL MAX. TEMP.	MAX. FORWARD DROP	MAX. REVERSE CURRENT
		1N1191A	22A	50V	150°C	1.2V at 60 amps.	5.0 MA
		1N1192A	22A	100V	150°C	1.2V at 60 amps.	5.0 MA
		1N1193A	22A	150V	150°C	1.2V at 60 amps.	5.0 MA
		1N1194A	22A	200V	150°C	1.2V at 60 amps.	5.0 MA
		1N1183A	40A	50V	150°C	1.1V at 100 amps.	5.0 MA
		1N1184A	40A	100V	150°C	1.1V at 100 amps.	5.0 MA
		1N1185A	40A	150V	150°C	1.1V at 100 amps.	5.0 MA
		1N1186A	40A	200V	150°C	1.1V at 100 amps.	5.0 MA
							at 150°C case temperature and rated PIV

For full information and applications assistance, contact your Delco Radio representative.

Newark, New Jersey
1180 Raymond Boulevard
Tel: Mitchell 2-6165

Chicago, Illinois
5750 West 51st Street
Tel: Portsmouth 7-3500

Santa Monica, California
726 Santa Monica Boulevard
Tel: Exbrook 3-1465

Division of General Motors • Kokomo, Indiana

DELCO
DEPENDABILITY
RADIO
RELIABILITY

Write in No. 151 on Reader Service Card at start of Product Preview Section

COAX PLUGS made of aluminum



Lighter weight (by 35 per cent), a SWR of less than 1.1 up to 11 mc. better moisture sealing and improved cable clamping mechanism are advantages of the ALTNC Series of coaxial RF plugs, says Cannon Electric Co., Dept. S/A, 3208 Humboldt St., Los Angeles 31, Calif. Assemblies available include plugs and cable sockets for either RG-58C/U cable or .75-in. Foamflex semi-rigid aluminum cable.

Adapters for matching the two cable types to each other or to bulkhead fittings are also available.

Write in No. 220 on Reader Service Card

ADAPTERS in handy kit

Eleven adapters covering most coaxial cable connectors in common use have been packaged in a transparent plastic box by Dage Electric Co., Inc., Dept. S/A, 67 N. Second St., Beech Grove, Ind. The kit is useful for laboratories, technicians, experimenters, and others.

Adapters fit these connectors: UG 49 A/U; UG 201 A/U; UG 636 /U; UG 273 A/U; UG 255 A/U; UG 83 /U; UG 146/U; UG 564 /U; UG 100-381-1; UG 924/U; and UG 2038-1.

Write in No. 221 on Reader Service Card

TEST FIXTURE for vibration studies



This "Tri-Mode" auxiliary test fixture is available in two sizes to accommodate models C25H and C10 vibration exciters, and is welded tubular steel construction. The larger unit, model Tm25, permits vibration testing of specimens up to 66 in long and 44 in wide, says MB Mfg. Co., Dept. S/A, Box 1825, New Haven 8, Conn.

The fixtures may be used for either vertical or horizontal testing.

Write in No. 222 on Reader Service Card

more on page 250



TEAMWORK

"To deny an enemy effective use of his submarines." This is Anti-Submarine Warfare, and the Navy today employs an integrated team of vehicles, each possessing specific, unique capabilities.

Bendix-Pacific is proud to have aided this team by developing Radar, Shipboard and Airborne Sonar, Underwater Ordnance, Surveillance, Navigation and Communication equipments for these various vehicles comprising today's ASW Task Group.



Multi-
Engineered
For Victory

We invite your inquiry regarding the excellent opportunities for engineers now available. Write: Mr. W. C. Walker, Engineering Employment Manager.

Check Employment Inquiry Form on Page 193

For greater reliability...

- *Precise heat control in sensitive electronic equipment*
- *Wide range temperature and altitude operation*
- *Compact integral design*

You can get all 3 in one unit
SMALLER THAN A BREADBOX.

It includes reservoir, pump, spring-loaded expansion chamber, heat exchanger, motor, fan, flow and pressure interlocks—designed, built and rigidly tested by PESCO.

Examine this integral PESCO cooling package as an example of the performance you can get through liquid cooling with Coolanol 45. Its heat transfer rate is high—2400 watts at sea level to 2000 watts at 50,000 feet. The package features a “wet motor” installation to eliminate pump seal leakage and also to add heat to the Coolanol 45 at low temperatures... a high-temperature cutout coupled with a low flow switch protects the electronic system... a low-temperature bypass valve lets the fluid bypass the heat exchanger at low temperatures.

In this and other PESCO cooling packages, Coolanol 45 delivers reliability in terms of wide liquid-phase operating temperatures (−65° F. to 400° F.); excellent heat transfer over the entire temperature range; dielectric properties for equipment protection; long component service life; excellent storage stability; good lubricity and compatibility with common materials of construction.



Size: 9 x 9½
x 8 inches

Model 144029-010 Performance Data

Coolant fluid: Coolanol 45
Liquid system pressure: 20 psig;
maximum 100 psig
Heat transfer: 2KW Mil-E-5400, Curve A,
Class One conditions
Liquid flow: 1.0 gpm
Air delivery: 325 cfm at sea level to
700 cfm at 50,000 feet
Size: 9 x 9½ x 8 inches
Fan speed: 5650 to 10,800 rpm
Power: 200 volt 3 phase—400 cycle
Power consumption: Fan and motor—
330 watts
Weight: 15½ pounds

*For greater reliability,
use COOLANOL 45
in these applications:*

SUBASSEMBLIES

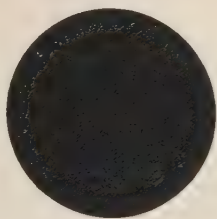
KLYSTRONS
MAGNETRONS
TRAVELING WAVE TUBES
SOLENOIDS
PULSE-FORMING NETWORKS
CONTROL UNITS

COMPONENTS

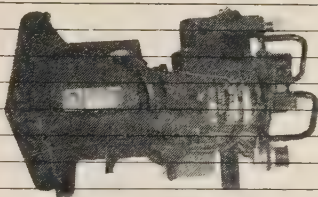
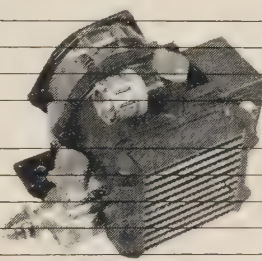
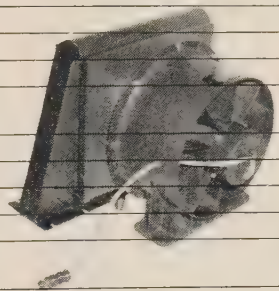
AMPLIFIERS
POWER SUPPLIES
SIGNAL DATA CONVERTERS
RECEIVER-TRANSMITTER UNITS
COMPUTERS
ANTENNA CONTROL UNITS

PESCO electronic cooling packages with COOLANOL 45

Other PESCO Coolanol 45 packages...small, tough, efficient, reliable!



Two of the units shown below are currently being used in missile ground support, the third in an airborne navigational system... all these systems rely on Coolanol 45 for precise temperature control, reliable operation.

MODEL 143733-030		
Coolant fluid		Coolanol 45
Liquid temperature range		160° F. maximum
Liquid system pressure		200 psig maximum
Heat transfer rate		600 BTU/min. at inlet temp. 160° F.; air temp. 125° F.
Liquid flow rate		8 gpm at 160° F.
Air delivery		3500 cfm, 4 inches WG pressure drop
Size		22¼ x 17 x 19 inches
Power		416 volts AC, 3 phase, 400 cycle
Speed	5500 rpm	
MODEL 143582-020		
Coolant fluid		Coolanol 45
Liquid temperature range		-40° to 200° F.
Liquid system pressure		25 psig; maximum pressure, 200 psig
Heat transfer rate		1806 BTU/hr. with 1 gpm; inlet temperature 170° F.; inlet air temperature 125° F. minimum
Liquid flow rate		1 gpm at 170° F.
Air delivery		70 cfm at 2 inches WG at fan exit
Size		7½ x 6 x 7 inches
Power		416 volts AC, 3 phase, 400 cycle
Speed	7800 rpm	
MODEL 143763-010		
Coolant fluid		Coolanol 45
Liquid temperature range		-65° to 250° F.
Liquid system pressure		8 psig; maximum pressure 45 psig
Heat transfer rate		250 watts with ¼ gpm; inlet temperature 250° F.; air temperature 160° F. continuous, 203° F. intermittent
Liquid flow rate		¼ gpm
Air delivery		7.5 lbs./min. at sea level; 0.75 lbs./min. at 70,000 feet
Size		4½ x 10½ x 6 inches
Power		200 volts AC, 3 phase, 400 cycle
Speed		Fan motor—8000 rpm at sea level; 20,000 rpm at 70,000 feet
Weight		Pump motor—11,000 rpm 7 pounds

SYSTEMS

FIRE CONTROL
RADAR (ground and airborne)
GUIDANCE
NAVIGATION
DATA-LINK
TELEMETERING
COMMUNICATIONS



Monsanto Chemical Company
Organic Chemicals Division
Dept. AV-13
St. Louis 66, Missouri

When you need a synthetic fluid, come to Monsanto—Creator of fluids for the future.

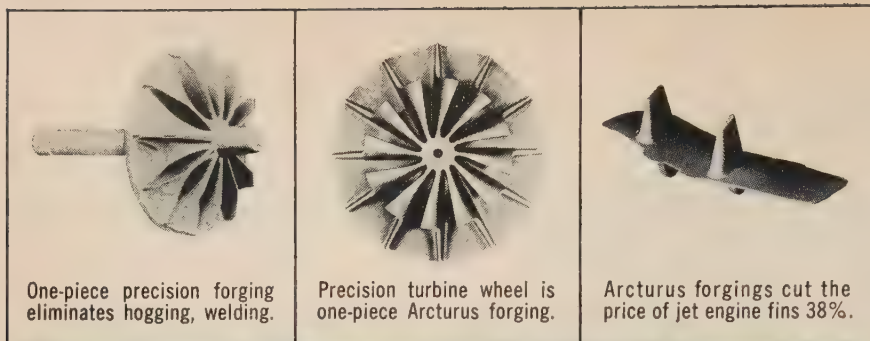
Coolanol 45: Monsanto T.M., Reg. U. S. Pat. Off.

Send for New Coolanol 45 Design Booklet

If your work involves temperature control of electronic equipment, investigate how Coolanol 45 packages can add far more reliability than air or water systems in airborne and ground electronic equipment.

For design information, send for the new "Design Tips on Liquid Cooling" booklet.

Write in No. 152 on Reader Service Card at start of Product Preview Section

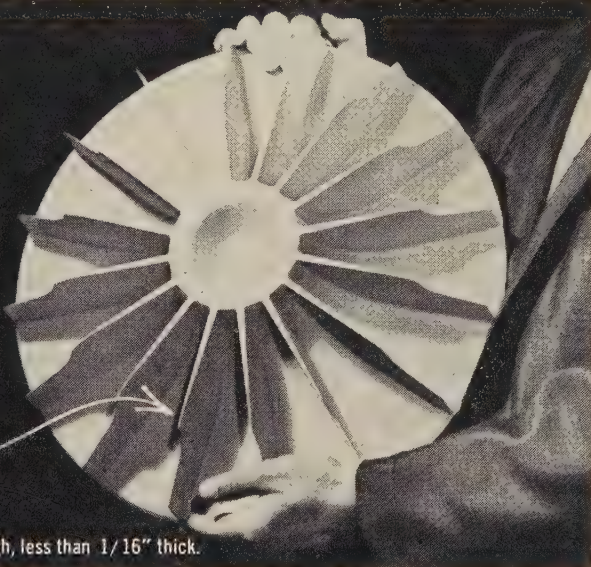


One-piece precision forging eliminates hogging, welding.

Precision turbine wheel is one-piece Arcturus forging.

Arcturus forgings cut the price of jet engine fins 38%.

**LOOK
at the
THIN
WALLS**

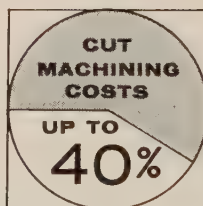


Aluminum impeller. Vanes 3" high, less than 1/16" thick.

CAN THESE BE FORGINGS?

*Arcturus is
Creating Forgings
Said to be Impossible*

HERE'S ONE RESULT →



PRECISION THIN WALLS AND DEEP DRAWS

Can these be forgings? They can — and are. Arcturus is creating forgings said to be impossible. How? Using remarkable new Arcturus forging techniques. The Result? Engineers are taking a long new look at the value and use of forgings. Strength? These new forgings are stronger because grain flow follows contours. Machining? It's reduced drastically — sometimes eliminated altogether. Materials? Most metals and high temperature alloys — 6150 steel; 19-9DL; A-286; M-308; Inco 901; René 41; 50% molybdenum — 50% tungsten; and others. How to get information? Send us your drawings and specifications.

FORCE AHEAD WITH

Arcturus



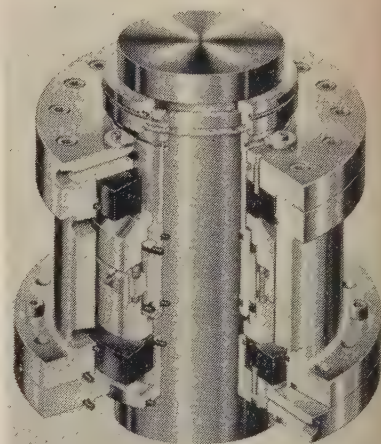
MANUFACTURING CORPORATION

4307 Lincoln Blvd., Venice, Calif. • Phone: Upton 0-2751

Write in No. 153 on Reader Service Card at start of Product Preview Section

PRODUCT PREVIEW

FUEL NOZZLE permits remote disconnect



A flow rate of 3000 gpm and a maximum pressure drop of 22 psi are available in this nozzle and fill valve for loading fuel, liquid oxygen or cryogenic fluid aboard aircraft and missiles, says **Parker Aircraft Co., Dept. S/A, 5827 W. Century Blvd., Los Angeles 45, Calif.** The valve design includes remote control of flow passage opening and closing, and remote disconnect.

Fail-safe over-ride controls are incorporated to prevent the nozzle from being opened when not connected and from being disconnected with valve or nozzle open. Leakage in the working pressure range is zero, and the valve features minimum spillage at disconnect. Changes in seal materials permit accommodation of a wide range of fluids. Size ranges are from two to eight-in. capacity. The assembly consists of nozzle and air-borne poppet valve.

Write in No. 223 on Reader Service Card

SHIELDING TAPE eliminates crosstalk

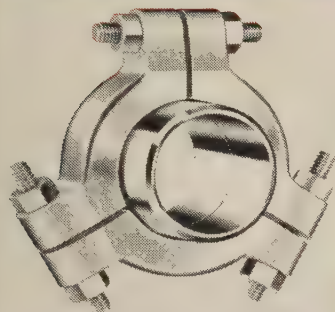
Metalshield is a new electrical shielding tape that eliminates the cross-talk of intercommunications systems in aircraft and elsewhere. The tape is far more effective in preventing inductance than other shielding materials and is over 50 per cent smaller, about 34 per cent lighter, and substantially easier to apply, says **The Dobeckmun Co., Dept. S/A, 3301 Monroe Ave., Cleveland 1, O.**

The effectiveness of the tape stems from its application as a solid wrap. As a result, all induced currents are directed to a drain wire, which can be attached to a ground. The tape consists of .00035-in. aluminum foil laminated to .0005-in. Mylar and slit into desired widths.

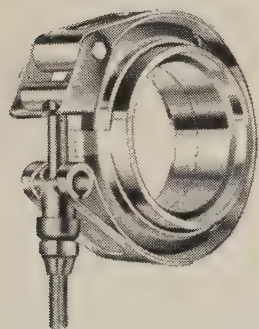
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more on page 252

NOW! A Complete New **MARMAN** Catalog of Aircraft/Missile Tube Joint Products

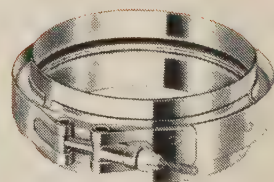
ALL PRODUCTS ILLUSTRATED ARE AVAILABLE FROM STOCK FOR IMMEDIATE DELIVERY



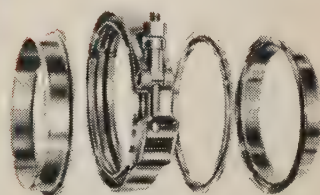
CONOSEAL PIPE JOINT



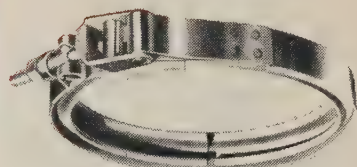
CONOSEAL TUBE JOINT



J-13 JOINT



J-11 JOINT



V-BAND COUPLINGS

Here is complete design information for aircraft and missile engineers working with tubing and duct joints. This new 40-page Marman Catalog No. 800 contains helpful design data plus full product information on these Marman products:

CONOSEAL Tube Joints for all fluid systems, including liquid metal, requiring a perfect seal under extremes of pressure and temperature.

CONOSEAL Pipe Joints for heavy-duty fluid systems on aircraft, missile and nuclear systems.

J-11 and LJ-11 Joints for positive seal of gaseous and liquid systems over a wide range of temperatures and pressures.

J-13 Joints for hot gas and air systems requiring a dependable seal.

V-Band Couplings and flanges in a wide range of sizes and styles for any fastening and joining application.

Order your copy today! Just fill in and mail the coupon below for quick service.

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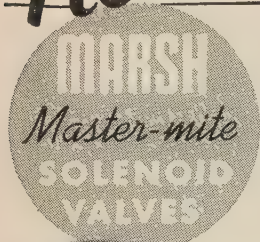
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SA-1

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New...from MARSH!



Conduit-type Master-mite. Grommet-type also available.

Small solenoid valves that fill a BIG order

Designed to meet the need for positive-acting tight-seating valves for use on wide variety of media, including oxygen, hydrogen, acetylene, etc.

Two Types:

Conduit type and grommet type. Port sizes 1/8" and 1/4" NPT.

Ten orifice sizes:

3/64" through 1/4".

Wide range of voltages:

Standard with 115 V. A. C. but also available in 12, 24, 208, 230, 460 V. A. C.

Pressure to 540 psi.

Small, but with more strength in the Marsh manner. Coils never overheat. Entire assembly leak tight. Remarkably quiet operation. Cleanable without breaking connections. Used in any position. Bodies either brass bar stock or 18-8 stainless steel. All moving parts stainless. Underwriters' approved for use on oxygen and hydrogen and as safety valves.

Write for new bulletin

MARSH INSTRUMENT COMPANY

Dept. 43, Skokie, Illinois

Division of Colorado Oil and Gas Corporation

Marsh Instrument & Valve Co., (Canada) Ltd., 8407 103rd St., Edmonton, Alberta, Canada, Houston Branch Plant, 1121 Rothwell St., Sect. 15, Houston, Texas.

Write in No. 155 on Reader Service Card

this NO-COST TEST OFFER has CONVINCED thousands

... send for YOUR FREE "TEST CAN" of C-5 "hi-temp" ANTI-SEIZE THREAD COMPOUND!



For one hundred and one aircraft uses such as slip joints, spark plugs, manifold studs, turbo blowers, jet engines, etc.

Try C-5 and see why leading aircraft manufacturers and thousands of industrial users have made it a part of their regular preventative maintenance program.

"HIGH-TEMP"

- ✓ Ends Seizing and Galling even up to 1800°F.
- ✓ Reduces Wrench Torque
- ✓ Ends Stud Breakage
- ✓ Permits Repeated Re-use
- ✓ Speeds Assembly and Disassembly
- ✓ Protects Stainless Steel at all Temperatures

ANTI-SEIZE THREAD COMPOUND

C-5's exclusive colloidal copper formula separates mating metal threads and surfaces with cushioning, protective copper plating. C-5 prevents galvanic action and eliminates pitting even when

dissimilar metals join. On mating metal surfaces, C-5 saves gaskets and countless man hours.

WRITE TODAY... For Your FREE Test Sample Can of C-5.

FELT PRODUCTS MFG. CO.

Dept. 52, P.O. Box 8609

Chicago 80, Ill.

Write in No. 156 on Reader Service Card

PRODUCT PREVIEW

CIRCULATOR TEES are lighter, smaller

The ferrite resonant post technique used in these ferrite circulator tees has resulted in lighter, smaller units that are more easily packaged into confined-area microwave systems, says Kearfott Co., Inc., Dept. S/A, 14844 Oxnard St., Van Nuys, Calif. The units offer exceptionally low insertion loss with high isolation.

The tees are adaptable for use as a configuration for a modulator or fast-acting switch, and can also be modified into a four-port circulator. Additional isolation can be obtained from a built-in isolation section. Typical specifications for a model in the series include: a frequency of 9.3 kmc plus or minus four per cent with isolation at I-III—15 db minimum, and insertion loss at I-II—one db maximum and at II-III—0.6 db maximum; and VSWR of I—1.15 maximum, and II—1.6 maximum.

Write in No. 225 on Reader Service Card

MINIATURE RELAY is highly sensitive

This TQA relay is said to be very sensitive and is intended for dc operation at sensitivities from 20 to 100 milliwatts. It has a contact rating with resistive load at 28 vdc, or 115 vac, according to Comar Electric Co., Dept. S/A, 3349 W. Addison St., Chicago 18, Ill. It has silver contacts, 3 amps; palladium or gold alloy, 0.5 amps.

Contact life is said to be a minimum of 100,000 operations; operating temperature —55 deg C to +100 deg C, but is available on special order in the range —65 deg C to +125 deg C. Shock resistant up to 50 G; vibration, up to 10 G, from 10 to 500 cps.

Write in No. 226 on Reader Service Card

GAGING MACHINE speeds operations

Complex missile shapes are among those that can be checked at any desired number of coordinate points of inner or outer surfaces by a new numerically controlled gaging machine designed to speed gaging operations, says Pratt & Whitney Co., Inc., Dept. S/A, West Hartford 1, Conn. The Data-Limit 6 Coordinate Measuring Machine, which is fully automatic, has two gaging arms, each capable of movement in the X Z and Theta coordinates.

Input data directing arm movement is provided by a perforated tape and the machine is equipped with digital readout. Use of a perforated tape eliminates the preparation of templates and other special gage tooling, and it permits fast, simple and economical part-to-part changeover. Overall gaging accuracy is said to be .000150 in. with a repeatability of .000050.

Write in No. 227 on Reader Service Card

PLASTIC SWITCHES have wide force range

The 5200 Series of precision snap-acting switches includes 19 models, ten of which cover an operating force range of three to 20 oz, according to Haydon Switch, Inc., Dept. S/A, Waterbury 20, Conn. These ten have their actuating button in center position.

The other nine have the button in off-center position and feature very low operating forces, from 2.5 to 60 gm. The miniature, plastic-case switches are qualified to the basic snap-action switch specification MIL-S-6743 and the vibration requirements of MIL-E-5272A, Procedure II. Electrical terminals are molded in place for maximum rigidity and resistance to movement, and a symmetrical housing ensures dimensional uniformity and stability. Close dimensional control makes the switches especially useful in ganging applications.

Write in No. 228 on Reader Service Card

more on page 256

CHR LS-53 SEALS ARE FUEL RESISTANT AND FUNCTIONAL AT -65°F TO 400°F

The unretouched photograph to the right illustrates the effect of MIL-F-5624C fuel, hydraulic fluid and engine oil on a CHR LS-53 seal and an organic rubber seal.

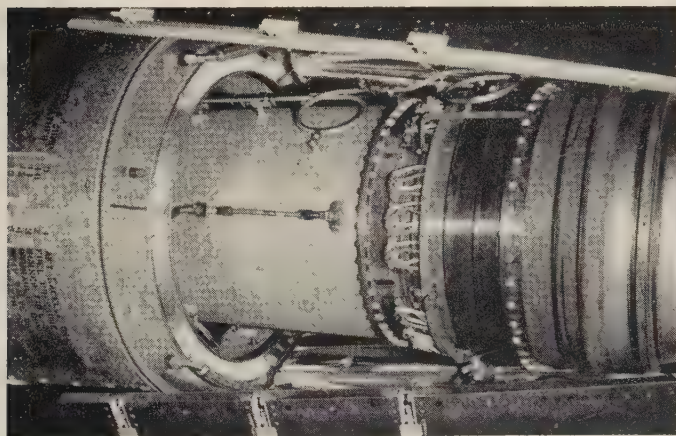
The CHR seal made of LS-53 fluoro-silicone rubber reinforced with Dacron fabric is unaffected; the organic rubber seal is destroyed.

LS-53 resists Skydrol 500 and is the first rubber to provide both fuel resistance and low temperature flexibility. Its tensile, tear and elongation properties approximate those of regular silicone rubber.

CHR produces fabric-reinforced LS-53 seals for airframe and engines in almost any construction required. If you have a seal application requiring weatherability, low temperature flexibility and resistance to fuels and solvents, write us today. Other made to order LS-53 products include sheets, moldings, extrusions, coated fabrics and release pads.

TESTS PROVE CHR LS-53 SEALS
UNAFFECTED BY EXPOSURE
TO FUEL, HYDRAULIC
FLUIDS AND ENGINE OIL
AFTER 70 HOURS AT 300°F .

ORGANIC RUBBER SEAL
BADLY DETERIORATED BY
EXPOSURE TO MIL-F-5624C
AMEND 1 FUEL, HYDRAULIC
FLUIDS AND ENGINE OIL
AFTER 70 HOURS AT 300°F .



Shown is a CHR LS-53 seal installation on the bulkhead and clam shell doors of the C-130 B engine. This seal gets soaked in hydraulic fluids and oils. CHR's LS-53 seal meets service requirements.

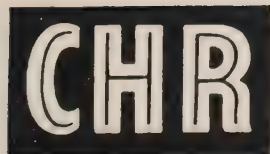


Lockheed's C-130B Transport can airlift missiles, men and supplies non-stop 4000 miles. This fast, rugged, long range airplane uses CHR LS-53 seals on engine doors and nacelles.



CHR specializes in the production of all types of silicone rubber airframe and engine seals for -100°F to 600°F temperature applications.

For design or production assistance with your sealing problems, write or phone CHR today. Our field representatives are available for direct contact.



COHRIlastic Aircraft Products: Airframe and engine seals, firewall seals and coated fabrics.

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Write in No. 158 on Reader Service Card at start of Product Preview Section

COMPACT CAPACITY

QUALITY COMPONENTS

Instant Self-Alignment . . . automatically compensates for mounting inaccuracies and constantly varying in-flight deflection of structural members, and assures full capacity available under misalignment to plus or minus 10°.

Full Radial Capacity . . . under all conditions due to rollers aligning themselves naturally, eliminating roller end wear and race surface scuffing.

High Thrust Capacity . . . without the need for auxiliary arrangements. End-thrust loading is taken on full roller contact area, not on inner race shoulders or retaining ring surfaces.

All Combinations of Load . . . are fully carried on bearing race surfaces, regardless of condition of misalignment.

Great Reserve Capacity . . . to meet abnormal shock and impact loads . . . is accomplished by increasing length of roller contact under greater loads, providing a vital safety factor for your design.

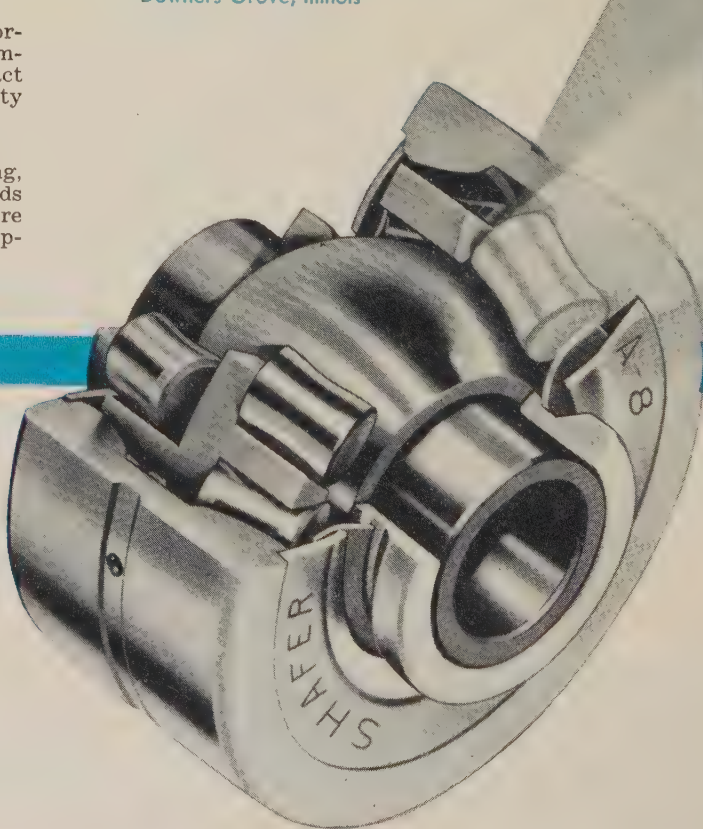
Positive Sealing . . . by true self-aligning, free-running seals and stainless steel shields that keep lubrication in, dirt and moisture out. Special seals for high-temperature applications.

Relubrication in Service . . . is easy with all Shafer Bearings. Outer race groove design allows relubrication without disassembly or removal from the air frame structure, extending service life three to ten times that of ordinary aircraft bearings.

Corrosion Resistance . . . of all exposed bearing surfaces . . . is assured by cadmium plating in accordance with current applicable government specifications.

Send for your free copy
of the New Shafer Aircraft
Bearing Catalog #59120.
Write Shafer Bearing Division,
Chain Belt Company,
Downers Grove, Illinois

SHAFER
DIVISION OF
CHAIN
BELT COMPANY



ize for Size, a SHAFER Aircraft Bearing Has More Capacity and Reserve..Longer Service



Outer Race . . . is made of SAE-52100 electric furnace bearing quality steel, heat-treated in controlled-atmosphere furnaces to produce working surfaces that are hard and tough.

Rollers . . . are of SAE-52100 steel heat-treated to assure optimum hardness and toughness. Rollers are electronically selected by size for every bearing assembly.

Inner Race . . . like rollers and outer race . . . is made, in one piece, from high-quality SAE-52100 steel heat-treated for normal service up to 300° F. For higher temperature operation, see page 4.

Sleeve . . . is heat-treated to provide a tensile strength of over 150,000 lb. per sq. in.

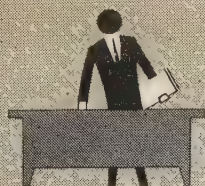
5. Retainers . . . for standard double-row Shafer Bearings . . . are die-cast Zamak or Beryllium Copper. See page 4 for high-temperature data.

6. Collars . . . of high-tensile-strength steel . . . serve as spacers for inner race and alignment stops, preventing seal damage.

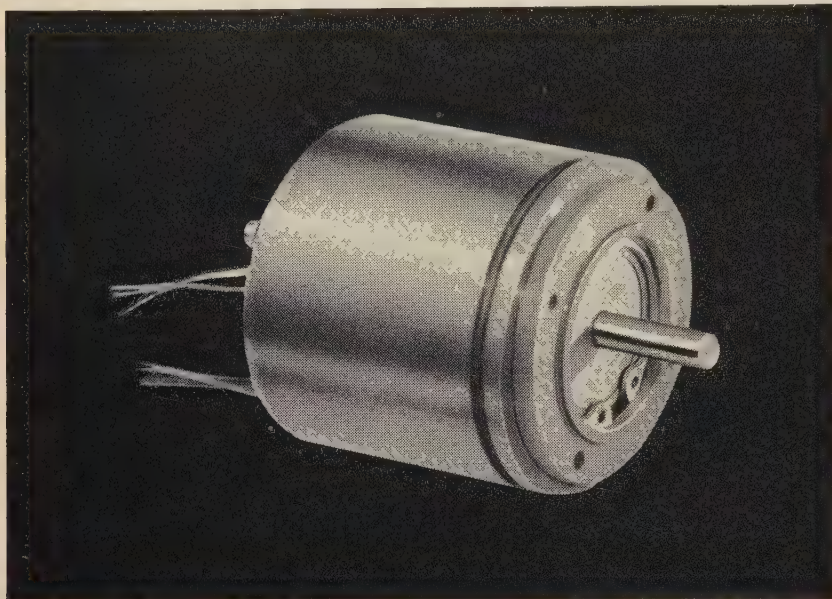
7. Seals . . . are Buna-N in all standard series, designed to permit relubrication of bearing without seal removal. For high-temperature seal data, see page 4.

8. Shields . . . contour-formed of stainless steel . . . provide extra seal protection for lubricated bearing surfaces.

Lighter than Any Other Bearing of Equal Weight and Envelope Dimensions
 Write in No. 159 on Reader Service Card at start of Product Preview Section



ENGINEERING REPORT ON BENDIX COMPONENTS



ONE-MINUTE SYNCHRO SYSTEM ACCURACY

Electrical two-speed Autosyn* synchro features—

- **ACCURACY UNAFFECTED BY THERMAL AND MECHANICAL STRESS**
- **HIGH SIGNAL-TO-NULI RATIO**
- **ELIMINATION OF GEAR ERROR FOUND IN MECHANICAL TWO-SPEED SYSTEM**
- **ADAPTABILITY TO GYRO PICKOFF**

Developed to meet need for accurate data transmission with maximum system simplicity. Produces two electrical outputs from single shaft, thereby eliminating inaccuracies of two-speed gear system as well as installation and maintenance costs of additional unit.

The synchro contains two separate sets of windings. One set pro-

duces the normal signal pattern of one cycle of output voltage, while the other produces eleven cycles, for each rotation of the synchro shaft. Increase in accuracy is very close to the 11-to-1 theoretical maximum, resulting in a system error of ± 1 minute when used back-to-back with similar units.

*REG. U. S. PAT. OFF.

ADDITIONAL CHARACTERISTICS:

Input voltage (to rotor)	26 volts, 400 cycles, single phase
Input current	200 ma max.
Input power	2.5 watts max.
Signal-to-null ratio	350:1
Sensitivity (mv/degree)	3500

For more detailed information on specific applications, write—

Eclipse-Pioneer Division

Teterboro, N. J.



District Offices: Burbank and San Francisco, Calif.; Seattle, Wash.; Dayton, Ohio; and Washington, D. C.
Export Sales & Service: Bendix International, 205 E. 42nd St., New York 17, N. Y.

Write in No. 160 on Reader Service Card at start of Product Preview Section

PRODUCT PREVIEW

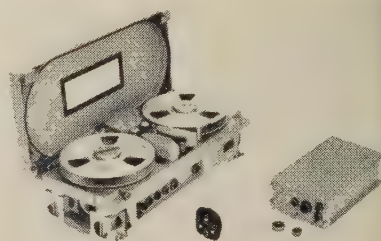
CHECK VALVE has double ball design

This new check valve prevents bleed-off of downstream pressure if both supply pressures fail, says The George W. Dahl Co., Inc., Dept. S/A, 86 Tupelo St., Bristol, R.I. Each of the valve's two inlets is immediately sealed by a separate ball.

The miniature #9061 double ball check valve is characterized by compact, rugged construction and low price. The valve body is rated for 100 psi maximum and 300 deg F, also maximum. Height of the unit is 1 3/8 in. and width, two in.

Write in No. 229 on Reader Service Card

AIRBORNE RECORDER is miniaturized



Two units weighing a total of 90 1/2 lbs make up the seven-track AR 200 airborne and mobile magnetic tape recorder announced by Ampex Corp., Dept. S/A, 934 Charter St., Redwood City, Calif. A selection can be made of up to 14 analog recording tracks, 32 digital tracks, or a combination of seven analog and 16 digital tracks on a single, one-in. wide magnetic tape.

The recorder, which uses solid state components and requires 1.6 cu ft of space, will operate despite high altitudes shock, and a wide temperature range.

Write in No. 230 on Reader Service Card

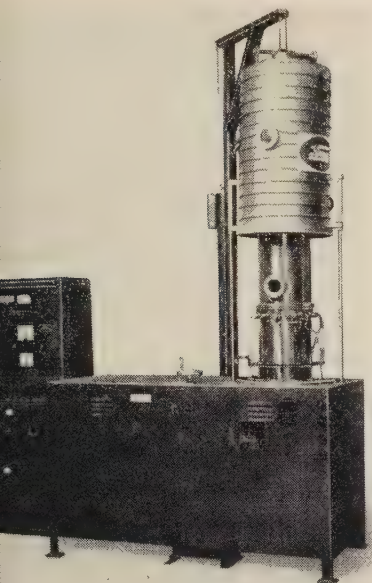
GRINDER is very precise

Finishes to three in. and repetitive accuracy to .0001 in. are readily obtainable with the MG12 cylindrical grinder, according to Bently Industrial Corp., Dept. S/A, 41 E. 42nd St., New York 17, N. Y. The Myford grinder, which has a capacity of 3 x 12 in. between centers and a swing of five in. is said to hold parallelism and roundness to millionths.

Features include a hardened and thread ground feedscrew with force lubrication; fine feed adjustments to dead stop to .000025 in.; extreme rigidity in holding work on dead or live centers; and automatic lubrication. Both wheel and workhead spindles rest in long-taper phosphor bronze, handscraped front journals, and twin angular contact pre-loaded bearings in the rear.

Write in No. 231 on Reader Service Card

VACUUM SYSTEM is very efficient



The Ultra High vacuum system presents the first offering of a practical working unit able to attain pressures of 1×10^{-9} Hg, or better, within a chamber that provides adequate work space for production or experimentation, says Kinney Mfg. Div., The New York Air Brake Co., Dept. S/A, 3529 Washington St., Boston 30, Mass. The working chamber, made of stainless steel, has a 12-in. diameter and is 18 in. high, and it is equipped with two windows, rotary motion, and electrical feed-throughs. The device's outer chamber can be evacuated to 1×10^{-5} mm. Pump down is rapid, and differential pumping permits the use of simplified seals. The dual chamber design has the advantage of housing heating elements and shielding for baking and outgassing the system.

Write in No. 232 on Reader Service Card

LOCKBOLT GUN has greater power

The G-87 lockbolt gun, an adaptation of the G-85, is a lightweight pulling tool designed to install lockbolts with pull-in and setting loads that exceed the capacity of other commercially available pneumatic lockbolt guns says Cherry Rivet Div., Wmsend Co., Dept. S/A, Box 57-Z, Santa Ana, Calif. The new gun is a short stroke, high pin break tool that develops up to 11,000 lbs of pull at 100-psi air pressure, and it can be used for up to 125 psi with a corresponding increase in pulling power. All lockbolts from $\frac{3}{16}$ through $\frac{3}{8}$ -in. diameter, including the five-groove high break load pin in all materials, can be installed by the 10½-lb tool which accepts pulling nose assemblies that are used with other guns.

Write in No. 233 on Reader Service Card

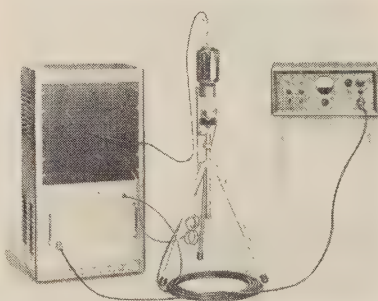
INSULATING TUBING withstands rough use

A silicon coating tough enough to withstand abnormally rough handling has made possible Turbo 117, an improved silicone rubber insulating tubing, according to William Brand & Co., Inc., Dept. S/A, Willimantic, Conn. The coating meets all MIL 1-2190, NEMA and ASTM specifications.

The tubing features excellent toughness, low-temperature flexibility, and abrasion and heat resistance, and it does not sacrifice any of the desirable properties of silicone rubber.

Write in No. 234 on Reader Service Card

FLASH X-RAY EQUIPMENT for high speed recording



This flash X-Ray equipment produces X-ray type shadow pictures of ballistic and high explosive fragmentation, "burning" pattern of solid fuel propellants used in rockets and missiles, says Zenith Radio Research Corp. of Calif., Dept. S/A, 841 Warrington Ave., Redwood City, Calif.

Radiation from flash X-ray tube lasts about one-sixth of a microsecond and is, at the time occurrence, under such precise control that the motion of a high speed projectile in flight may be completely stopped at precisely the desired position.

Write in No. 235 on Reader Service Card

DIE-CASTING ALLOY for high temperature

A unique die-castable alloy of the magnesium-thorium group has been developed for service above 500 deg F, says The Dow Chemical Corp., Dept. S/A, Midland, Mich. Alloy HM11XA is reported to retain good mechanical properties through 800 deg F, and it has been used for parts that have been evaluated for aircraft and missile applications.

The alloy has a density of 0.064 lbs/cu in. and has shown, in test bar form, an average tensile strength of 30,200 psi at 70 deg F and 7800 psi at 800 deg F. Composition is about one percent thorium, one percent manganese, and the balance, magnesium.

Write in No. 236 on Reader Service Card

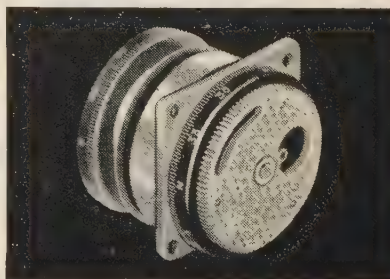
more on next page

ENGINEERING
REPORT
ON OTHER BENDIX
COMPONENT PACKAGES



CAM COMPENSATOR

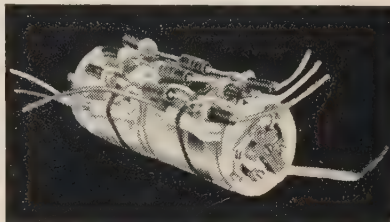
Efficient compensating device for servo system error.



The type CP-20-A1 is a simple, entirely mechanical means of correcting an output data shaft in relation to either servo loop errors, sensing errors, or known environmental factors affecting the system. Eliminates need for adjusting remotely placed or inaccessible units. Ask for full details.

CLUTCHED SYNCHRO

Transmits corrective signal, or establishes new reference.



The type CP-4-A1 is an integrated unit containing a high-precision pygmy Autosyn* synchro and an electro-magnetic clutch. Has general systemic application where it is desired to transmit a corrective signal, or to establish a new reference as a result of a temporary condition. Removal of electro-magnetic clutch excitation instantly re-establishes Autosyn, or signal source, at zero. Three unit-mounted resistors provide for proper output voltage as well as correct phase relationship of output voltage to excitation voltage. Write for further information.

*REG. U. S. PAT. OFF.

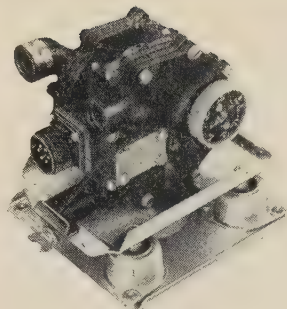
Manufacturers of
GYROS • ROTATING COMPONENTS
RADAR DEVICES
PACKAGED COMPONENTS
INSTRUMENTATION

Eclipse-Pioneer Division



Teterboro, N. J.

Write in No. 161 on Reader Service Card



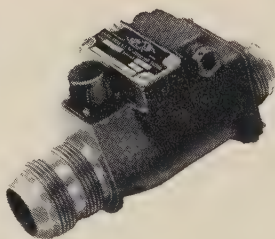
Altitude-Speed
Pressure Switch



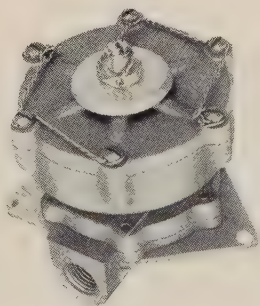
Pitot Tube
Disconnect



Dual Float Switch



Flow Indicating Valve



Regulating Valve



Composite Disconnect

AEROTEC PRECISION EQUIPMENT

Aerotec designs and makes compact, light equipment that meets today's severe aircraft and missile specifications. Aerotec's engineering knowledge and manufacturing skill can help solve your next problem. We'll gladly work with you to develop new equipment that meets your toughest space, weight and performance requirements.



AEROTEC INDUSTRIES, INC.

AIRCRAFT EQUIPMENT DIVISION, DEPT. S, GREENWICH, CONN.
CANADIAN AFFILIATE: T. C. CHOWN LIMITED, MONTREAL & TORONTO

Composite disconnects, pressure switches, level switches, nuclear components, valves (regulating, flow-indicating, vent, solenoid, motor-actuated).

Write in No. 162 on Reader Service Card at start of Product Preview Section

PRODUCT PREVIEW

MOTOR is explosion-proof

This totally enclosed explosion-proof motor, designed for 200/115 ac 400 cps, 3 phase operation, is rated at ½ hp at 4500 rpm +5 per cent, according to Western Gear Corp., Electro Products Div., Dept. S/A, 132 W. Colorado St., Pasadena, Calif. It has a minimum of 1000 hours life and incorporates permanently lubricated shielded ball bearings with corrosion resistant shaft. The motor measures 6.5 in in length by 4¹⁵/₁₆ in diameter. It is identified as Model 38VCG3.

Write in No. 237 on Reader Service Card

DUAL-BEAM KRT for high altitude



The dual-beam EIA Type 5BFP cathode-ray tube is a fast-writing device for high altitude aircraft, oscilloscope and indicator use, says Allen B. Du Mont Laboratories, Inc., Dept. S/A, 750 Bloomfield Ave., Clifton, N.J. Linear post acceleration is incorporated to provide minimum pattern distortion of the two independently controlled beams.

Typical operating voltages are post accelerator, 13,250 V; accelerator, 2,750 V; and focusing electrode, 600 to 900 V. The tube is available in P1, P2, P7 and P11 phosphors, and it has an aluminized screen.

Write in No. 238 on Reader Service Card

THERMOSTAT for missiles

This miniature, hermetically-sealed thermostat features a completely welded construction and is independent of solders, fluxes or organic materials. Its special high vibration resistant construction tests to 25g's in a frequency range of 75 to 3,000 cycles per second. The actuating device is a snap-acting bimetallic disc, according to Texas Instruments, Inc., Metal & Controls Div., Dept. S/A, Attleboro, Mass. Gold electroplated contacts are used for dry circuit applications and for the assurance of long storage life.

Rating is 5 amps max./30 vdc, 100,000 cycles min. Opening tolerance is +5° F and closing tolerance +4° F.

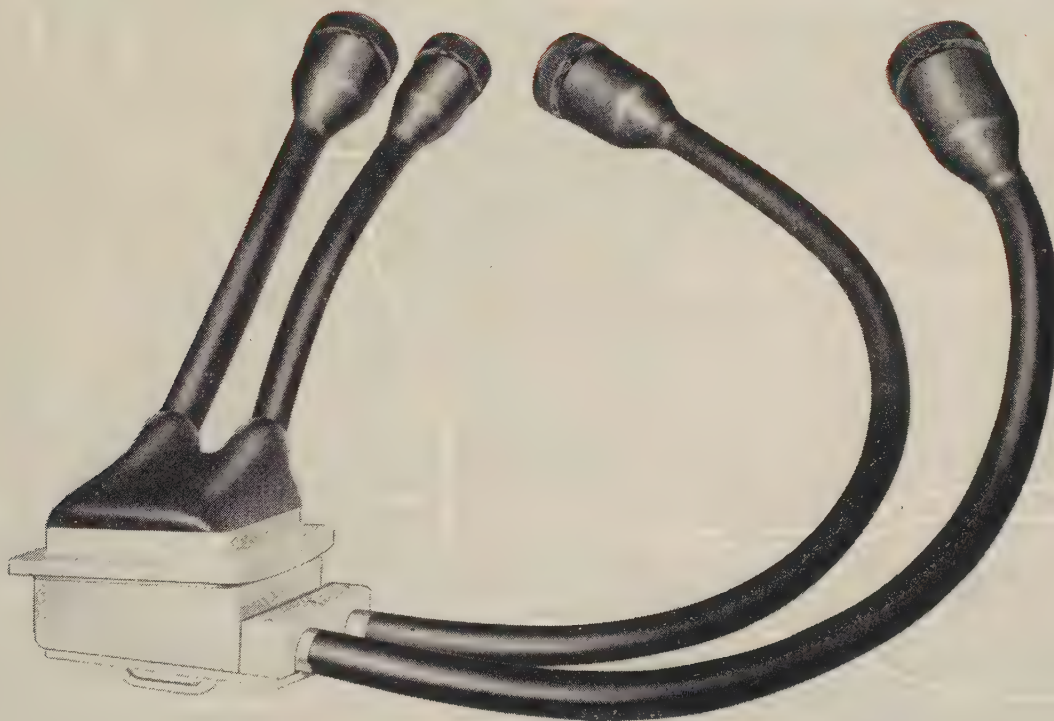
Write in No. 239 on Reader Service Card

more on page 262

for an extension in Reliability

engineered...

CANNON PLUG/HARNESS SYSTEMS



SINGLE RESPONSIBILITY FOR PERFORMANCE OF PLUG/HARNESS SYSTEMS...RELIABILITY GUARANTEED!

CANNON PLUG/HARNESS SYSTEMS are designed and manufactured under rigid, quality-controlled conditions in a separate, highly specialized facility completely equipped to handle all phases of design, development and manufacture. As a single source supplier for both plugs and harness assemblies, Cannon can assume complete responsibility for the reliability of the "Cannon Plug/Harness System" as a whole.

COMPLETE TESTING FACILITIES: Extensive testing equipment is so available to duplicate environmental conditions. These include vibration tests, temperature cycling tests, and heat flux tests duplicating heat re-entry conditions. Each system is 100% tested for continuity and for high potential and insulation resistance, shorts or grounds as well as humidity, VSWR, contact retention, etc. Certified test reports are available.

SPECIAL DESIGN SERVICES: Because Cannon is a single source supplier of the plugs and completes the termination, it is possible to select and recommend cables and termination techniques designed to custom-match the proper plug for the assembly. The complete assembly can thus be manufactured and tested under conditions prohibited to single-source suppliers.

■ **FASTER DELIVERY—NO COST PYRAMIDING:** A special, separate facility devoted to umbilical and harnessing production offers the most up-to-date production techniques to provide the industry's fastest delivery—plus no pyramiding of costs. Customers draw on Cannon's capabilities as the world's largest exclusive manufacturer of electrical plugs.

■ **FIELD TECHNICAL ASSISTANCE:** Experienced specialized sales engineers are available to discuss and assist customers in the technical aspects of plug-harness system requirements prior to manufacture and after installation in the field.

FOR FURTHER INFORMATION on Cannon Plug/Harness Systems write for Cannon Catalog HC-1—Cannon Electric Company, 3208 Humboldt Street, Los Angeles 31, Calif. Please refer to Department 115.

CANNON ELECTRIC COMPANY
—Factories in Los Angeles, Santa Ana, Salem, Toronto, London, Paris, Melbourne and Tokyo.

Distributors and Representatives in principal cities of the world.

CANNON PLUGS



Write in No. 163 on Reader Service Card at start of Product Preview Section



| *Now in magnesium and aluminum*

FOUR DOW PLANTS OFFER AIRCRAFT AND MISSILE MEN WIDE CHOICE OF MAGNESIUM WARES

Coiled sheet, thin wall castings, many other production items are now available from Dow's big rolling mill, foundry and fabrication facilities.

Aircraft and missiles manufacturers on the alert for improved materials and production methods would enjoy a personal tour of the four Dow plants that turn out magnesium products. Next best thing is this quick rundown on the new ways of forming and fabricating magnesium now being practiced in these plants to open up new uses for the lightweight metal . . .



TOOLING PLATE, extra flat, is annealed to eliminate residual stresses.

At the huge Madison, Illinois, rolling mill, for example, they're making magnesium sheet that doesn't require stress relief after welding. This is a major step forward in light metal technology and a boon to manufacturers using magnesium assemblies. Madison has also increased the maximum width of sheet to six feet. Five different sheet alloys, including elevated temperature alloys, are now available either flat or in coils.

To keep abreast of the rapidly increasing demand for precision

jigs and fixtures, Madison keeps a close watch on the tolerances of Dow magnesium tooling plate. Typical flatness tolerances, for example, are 0.010 inches in any six feet. This means greater accuracy and less machining for users of Dow tooling plate. Madison is now turning out both magnesium and aluminum extrusions that cover a wide range of sizes: from delicate precision parts to a 30-inch circumscribed circle size—made by Madison's mammoth 13,200 ton extrusion press.

Over in Bay City, Michigan, interesting things are happening, too. At the well-equipped Dow magnesium foundry, largest in the U. S., sand and permanent mold castings of all sizes and shapes are being produced on a volume basis. Complete facilities are maintained for heat treatment, styrene DMI impregnation and chemical treatment. A well-staffed quality control team makes sure that all specifications are met or exceeded, and that the most modern equipment and techniques are fully utilized.

The Bay City foundry casts many complex and difficult designs. Large castings with walls as thin



DOW FOUNDRY offers production capacity for sand and permanent mold castings of all sizes.

as 0.100 are now being produced. Other useful developments include cast-in tubeless passageways for use as hydraulic lines, special coring techniques for casting enclosed shapes, and new magnesium casting alloys.

A new die casting plant is now on stream at Bay City. This facility houses the most advanced magnesium die casting equipment, including cold chamber metering units which automatically feed metal to the machines and contribute to unusually high production rates. To assure close alloy composition control on both die casting plant and foundry, a direct reading spectrometer provides frequent and precise analyses of the molten metal. Similarly, X-ray equipment is also available where radiography is needed in quality control.

The Dow fabrication plant, also in Bay City, offers capacity for volume work on magnesium assemblies. Here, too, developmental work on magnesium is constantly in progress. The plant is set up to handle large or small jobs, and plenty of both. Its activities include deep drawing, bending, spinning, stamping, piercing, machining, arc and spot welding, assembly, chemical treatment and painting. This plant has pioneered many "firsts" in magnesium production, such as hot drawing, spot welding and automatic welding.

For more information about Dow's magnesium production facilities, contact the nearest Dow sales office or THE DOW METAL PRODUCTS COMPANY, Midland, Michigan, Merchandising Department 1000EW1.



THE DOW METAL PRODUCTS COMPANY

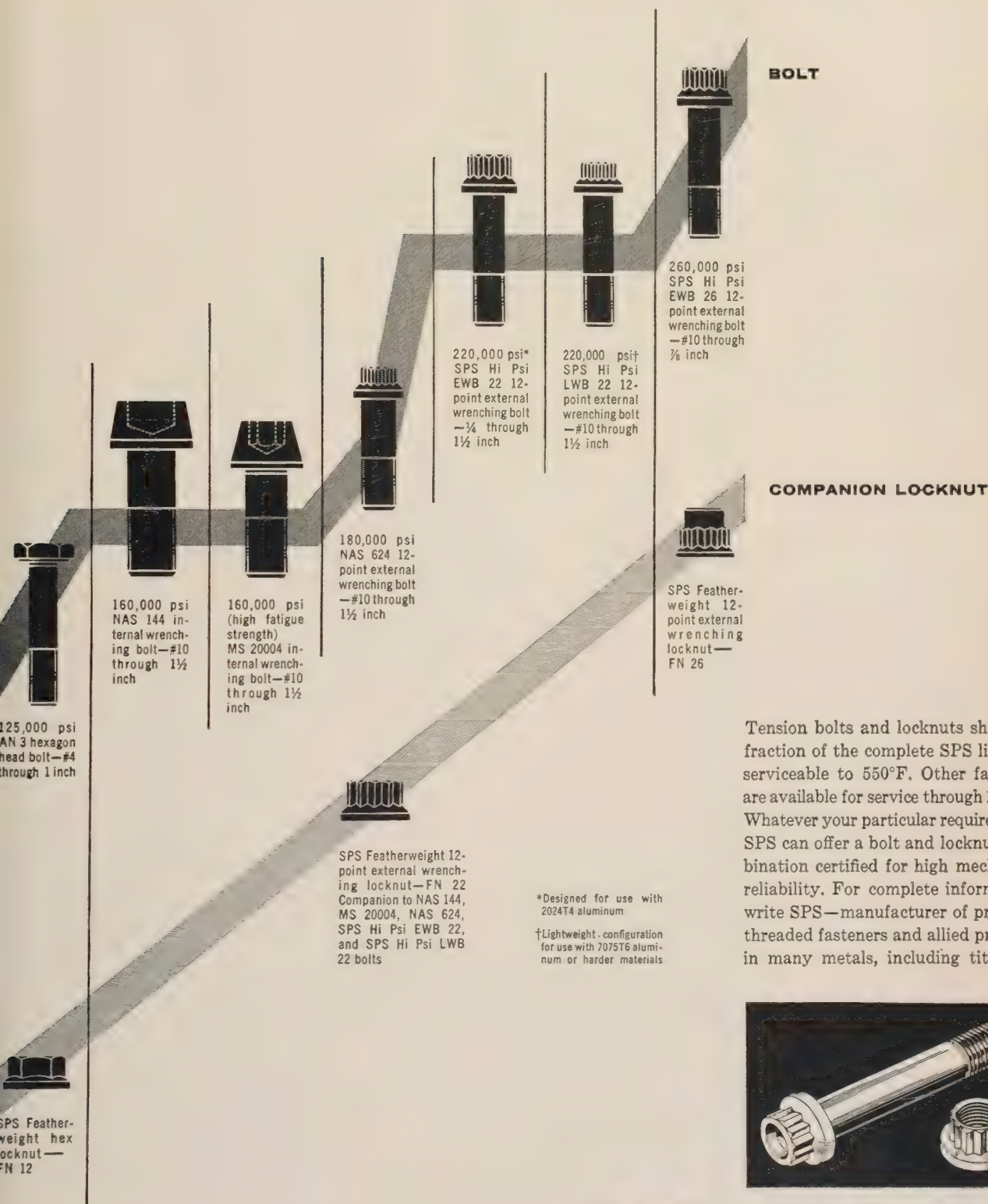
Division of The Dow Chemical Company

Write in No. 164 on Reader Service Card at start of Product Preview Section

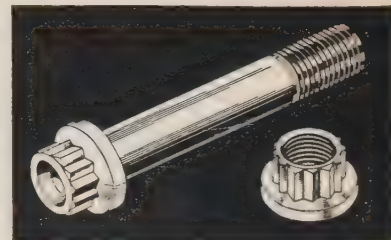
SPACE/AERONAUTICS

Just name the tensile strength...

SPS offers a tension bolt and companion locknut for every application up to 260,000 psi



Tension bolts and locknuts shown (a fraction of the complete SPS line) are serviceable to 550°F. Other fasteners are available for service through 1600°F. Whatever your particular requirements, SPS can offer a bolt and locknut combination certified for high mechanical reliability. For complete information, write SPS—manufacturer of precision threaded fasteners and allied products in many metals, including titanium.



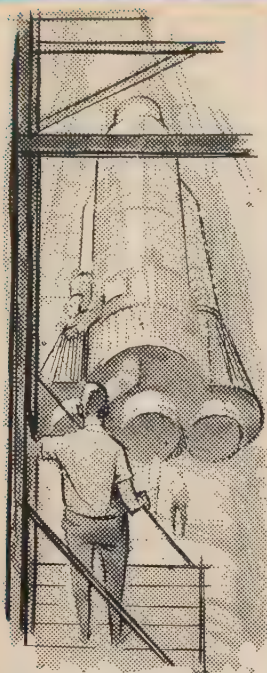
AIRCRAFT / MISSILE Division

SPS

JENKINTOWN 54,
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SPS WESTERN,
SANTA ANA, CALIFORNIA

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Electronic Field Engineers YOU'RE IT!

When you become a FIELD ENGINEER with Convair/Astronautics you become the man with the Atlas answers . . . the technical troubleshooter . . . the man who aids the Air Force on the spot. Your greatest reward: the immediate satisfaction of coming to grips with each problem . . . of meeting and solving it at close range.

You will first be thoroughly trained in Atlas systems in San Diego. Field assignments, commanding attractive bonus allowances, will follow at Vandenberg AFB, Santa Maria, California; Warren AFB, Cheyenne, Wyoming or at Offutt AFB, Omaha, Nebraska. Other assignments will be available as additional bases are activated.

Men with engineering degrees and missile or aircraft hardware experience — men like you — are urgently needed now.

Write now to Mr. T. W. Wills, Engineering Personnel Administrator, Department 130-90

CONVAIR ASTRONAUTICS

Convair Division of

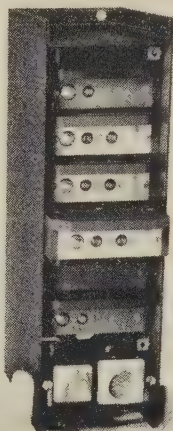
GENERAL DYNAMICS

5593 Kearny Villa Road,
San Diego, California



PRODUCT REVIEW

SIGNAL CONDITIONER for airborne devices



This miniature signal-conditioning system for airborne telemetry and tape applications features transistorized dc, ac or carrier amplifiers. It is designed with a six-channel modular case that accepts any combination of solid-state amplifiers, says Neff Instrument Corp., Dept. S/A, 2211 E. Foothill Blvd., Pasadena, Calif.

The Neff Scamp System produces zero to five V from mv inputs to drive voltage-controlled oscillators or record amplifiers. The dc amplifier features isolated input and high common-mode rejection, and the ac unit has an output biased at ± 2.5 V above ground. Output signal is limited at zero and five V to prevent overdriving a voltage-controlled oscillator. Power needed is unregulated 28 V dc.

Write in No. 240 on Reader Service Card

HALLTRON UNIT has wide thermal range

High gauss sensitivity and a range of -65 to $+125$ deg C are possessed by the Type HR-31 Halltron, a solid state device that is recommended for use in flux measuring equipment, analog multipliers, power meters, and other applications requiring a low temperature coefficient of Hall Effect, says Ohio Semiconductors, Inc., Dept. S/A, 1035 W. Third Ave., Columbus 8, O. The device has an output that is the product of an electrical current passing through the element and an applied magnetic field.

Features include: High resolution with no hysteresis; very low noise; a control current of 500 ma maximum; and a temperature coefficient of 0.1 per cent over the temperature range. Typical output for the HR-31 is 0.35 V.

Write in No. 241 on Reader Service Card

more on page 264

The Drill Sarge Says...



You bet
you can drill
high tensile
alloys with
**NEW YORK
DRILLS**

*They're made extra
tough to handle hard
abrasive metals*

New York has successfully developed high speed drills that do an efficient, economical job in 17-7, 19-9, Inconel X and Titanium. We also make drills which have proven their ability to perform well in such extreme high tensile alloys as Thermold A, Vasco Jet 1000, Renne 41 and A286.

These New York drills cut clean with each hole perfectly round, exactly on size and without burrs on the break through. There's less breakage too, which means drills last longer and give you more holes.

New York stocks a complete range of standard and special drills, all available at a savings over your current twist drill bill. If you wish further information, one of our sales engineers will be glad to call on you.



NEW YORK TWIST DRILL COMPANY, INC.

278 Lafayette Street, New York 12, N.Y.

MIDWEST OFFICE:

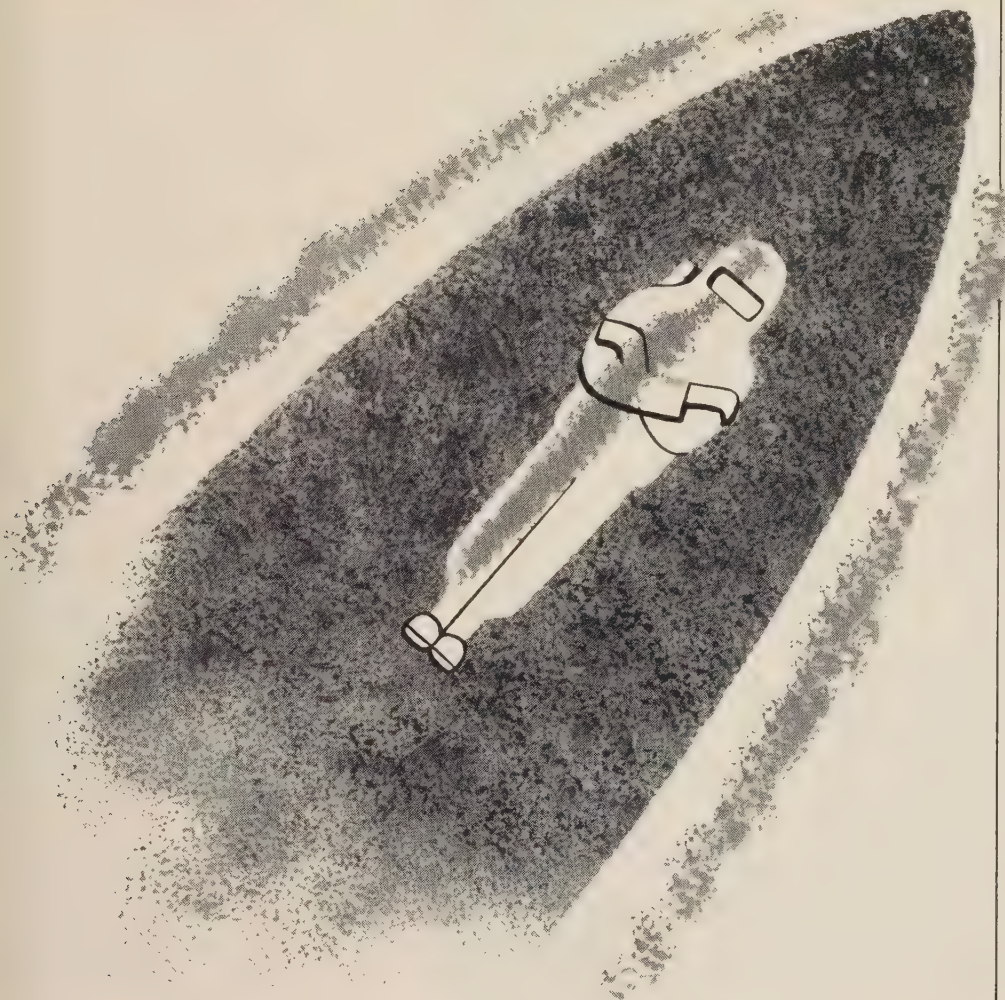
30-A N. Clinton St., Chicago 6

WESTERN OFFICE:

3537-A E. Olympic Blvd., Los Angeles 23

Solve your insulation and permeability problems with **SMR**

SMR



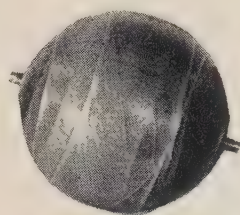
Stoner's SMR has broken through the thermal sealant barrier that has faced the missile and rocket industry for many years.

The varied shapes and forms that this versatile material has taken includes: chamber sealants; liners; insulation for head closures; high temperature insulation; prefabricated proofed sleeves and bladders, as well as other critical applications for rocket components.

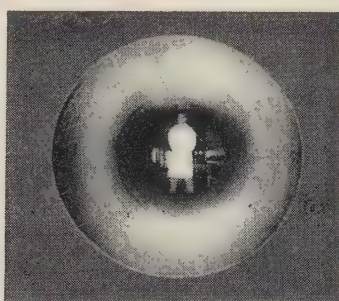
SMR is also being used to advantage in plastic molding compounds and pre-preged laminates.



NEW APPROACH TO DEPENDABLE NOZZLE PERFORMANCE utilizes the flexibility and toughness of SMR, in combination with other high temperature materials, in order to achieve predictable ablation rates.



100% RELIABLE BLADDER FOR FILAMENT-WOUND PRESSURE VESSELS. SMR is pre-proofed at Stoner prior to shipment.



SMR PROVIDES A TOUGH THERMAL LINER AND RELIABLE SEALANT FOR MISSILE AND ROCKET CHAMBERS. This unique rubber has exceptional high bond strength at elevated temperatures.



FREE IDEA CATALOG. Technical information on SMR and other Stoner products in this 24 page catalog will help you solve your rubber problems. Write for your copy today!

The finest in Engineered rubber

A subsidiary of CARLISLE CORPORATION



STONER RUBBER COMPANY, INC. 10792 Knott Ave.
Anaheim, California

Photos courtesy of Aerojet-General Corporation

*SMR is a special Silicone Modified Rubber produced by Stoner Rubber Company, Inc.

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NEW ENDEVCO VIBRATION SYSTEMS

Featuring: Transistorized charge amplifier and hermetically sealed accelerometer. You can use up to 300 feet of cable between amplifier and accelerometer—with no signal loss.

Complete Endevco system qualifies to MIL E-3272. Temperature range -40°F to $+230^{\circ}\text{F}$. Frequency response from below 10 cps to above 10 KC. Entire system isolated from ground.

Endevco System Amplifiers and Transducers are described in the "2200" and "2600" literature. Write for your copies today.

dynamics instrumentation



ENDEVCO CORPORATION

Department M
161 East California Boulevard
Pasadena, California

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PRODUCT PREVIEW

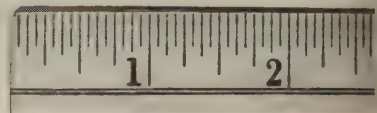
RELIEF VALVE for reverse free flow

This inline relief valve, designated P/N 52-131, allows free flow in the reverse direction, is light weight, compact, and highly reliable, according to Arkwin Industries, Inc., Dept. S/A, 648 Main St., Westbury, N. Y. System pressure up to 3000 psi, proof pressure 6075 psi, and burst pressure over 10,125 psi, it is said.

Rated flow pressure is 3850 psi at 27 gpm, reseal pressure 3100 psi min at 3.0 cc/min. Pressure drop 150 psi at 15 gpm reverse flow. Operating temperature range -65°F to $+275^{\circ}\text{F}$. Weight is 0.67 lb.

Write in No. 242 on Reader Service Card

TERMINALS resist severe humidity



A double turret-type solder terminal securely seated in Teflon for exceptional humidity resistance is featured in the terminal units 1945, 1946 and 1947, according to Cambridge Thermionic Corp., Dept. S/A, 445 Concord Ave., Cambridge 38, Mass. Mounting stud styles include external threaded, rivet type, and internal threaded.

All three types are about $\frac{3}{8}$ in. dia. The external threaded and rivet types are $\frac{1}{16}$ in. high when mounted, and the third type is about $\frac{5}{8}$ in. high. Mounting studs and solder terminal are brass and terminals are normally lead tin solder plate.

Write in No. 243 on Reader Service Card

VARNISHED TUBING has greater flexibility

A Class B polyester varnished fiberglass tubing that is compatible with the new high-temperature wire enamels, glass-served wire and polyester resins has been developed by L. Frank Markel & Sons, Dept. S/A, Norristown, Pa. Hygrade Polytube is reported to have greater flexibility than ordinary polyester varnished tubing.

The new tubing shows excellent resistance to acids, alkali, and moisture, and it is unaffected by hot or cold transformer oils.

Write in No. 244 on Reader Service Card
more on page 266



Jet Engine Hot Spots Torture Superior Super Alloy Tubing

Tubing must not take a permanent set or rupture

temperatures up to 1800°F torture the Superior Super Alloy tubing used as fuel lines to spray nozzles and as spray bars for afterburners in a current model jet engine. High oxidation resistance and strength at elevated temperatures are a must. Of even greater importance is the ability of the tubing to resist taking a permanent set or rupturing under the high stresses developed in service.

Rockwell Aircraft Co.'s Engine Accessories Division, Cleveland, with our cooperation, chose the analyses. Service conditions and fabrication requirements limited them to two: N-155,* 21% chromium, 20% nickel, 20% cobalt, balance iron—plus columbium; Haynes No. 25,† incl. approx. 20% chromium, 10% nickel, 15% tungsten, balance cobalt. Both

have excellent oxidation resistance, stress rupture characteristics, high strength at elevated temperatures.

N-155 tubing, as produced by Superior, was selected for the fuel lines because it is amenable to bending and shaping without cracking and is easier to braze. It is also used for the spray bars operating in temperatures under 1300°F because it is easier to drill. When higher temperatures are encountered by spray bars, Haynes No. 25 tubing is used.

Superior Super Alloy Tubing, in a wide range of standard and special analyses, in ODs ranging from .012 through 1.125, is available in both Seamless and WELDRAWN® types. Bulletin 70 describes them in detail. Write us for your copy. Superior Tube Company, 2038 Germantown Ave., Norristown, Pa.

Superior Tube

The big name in small tubing
NORRISTOWN, PA.

All analyses .010 in. to 5/8 in. OD—certain analyses in light walls up to 2 1/2 in. OD

West Coast: Pacific Tube Company, Los Angeles, California • FIRST STEEL TUBE MILL IN THE WEST

Write in No. 169 on Reader Service Card at start of Product Preview Section

*Reg. U.S. Patent Office, Union Carbide Corp.
†Reg. U.S. Patent Office, Haynes Stellite Co.

The Sign of the Kame

In the Japanese Shinto religion the sign of Kame (the Tortoise)



is the symbol of longevity. On the contemporary scene, the letters M.R.C. also mean longevity... longevity guaranteed by creative design and precision manufacturing. The all-new, wide band D.C. Amplifier fulfills a critical need of missile and aircraft design engineers for a stable, drift-free and multipurpose amplifier with a wide range of response. The M.R.C. D.C. Amplifier utilizes static, magnetic modulation instead of the usual electro-mechanical chopper. This results in an inherently rugged design.

SPECIFICATIONS

Input (nominal).....0 to 5 millivolts D.C.
Output.....0 to 5 V D.C.
Excitation.....28 V D.C. (unregulated)
Linearity..... $\pm 1\%$
Total Gain.....0-1000
Pass Band.....flat beyond 100 cps
Gain Stability & Zero Drift....better than 1%

For additional information on M.R.C.'s complete line of magnetic and transistor amplifiers, write for Data File MA-1000.

MAGNETIC RESEARCH CORPORATION

Pacing the Industry in Astro-Magnetics

3160 WEST EL SEGUNDO BOULEVARD, HAWTHORNE, CALIFORNIA

Write in No. 170 on Reader Service Card at start of Product Preview Section

RADAR ANTENNA is rugged, reliable



This fully ruggedized, mobile X-band radar antenna will operate under the severest environmental conditions, says Underwood Corp., Dept. S/A, 15330 Oxnard St., Van Nuys, Calif. The Model 8340 was designed for use in a tactical weapons system, and it operates over a 8750 to 10,500-mc range.

It has a power-handling capacity of 300 kw peak power when it is operated unpressurized. Standard polarization is linear, and it is adjustable to any orientation. Circular polarization types are also available. Features include a gain of 37 db at mid-band frequencies, scanning rates of up to 80 cps, simplicity and reliability, and a design that results in just one moving part. Standard output is two-speed synchro in both 360-deg azimuth travel and the 180-deg elevation travel.

Write in No. 245 on Reader Service Card

SHAFT ENCODER has new readout

The Model ES-100 incremental shaft encoder is one of a series devised with a unique magnetic, non-contacting readout system, says Applied Science Corp. of Princeton, Dept. S/A, P. O. Box 44, Princeton, N. J. The readout technique makes the encoder immune to the effects of contact wear, dirt and dust, humidity, temperature, altitude, pressure, vibration, acceleration, and shock.

Accuracy and life are independent of the length of time of operation whether readout is made in a moving or stationary system. The ES-100, which provides a 100-pulse output for 360-deg shaft rotation, has application as a velocity indicator, shaft position digital encoder, or multi-turn encoder. Capabilities extend to the reading of shaft angle in navigation devices, radar remoting, data-logging equipment, and process control instrumentation.

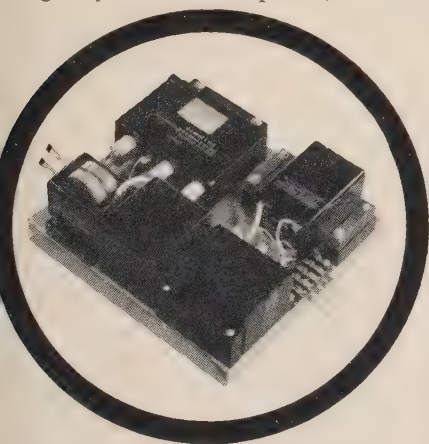
Write in No. 246 on Reader Service Card



Speaking of longevity...

M.R.C. offers a new series of Solid State Pulse Modulators for timing circuits, search radar, airborne radar and missile guidance.

One outstanding member of this group is the Model MP505 Airborne Pulse Modulator. This unit is used as a pulse modulator for high power missile beacons. Using only 250 watts of power, this effi-



cient unit provides 15KV pulses into a MA206 magnetron load. The pulse width is .25 microseconds at a repetition rate of 2000 pps.

The MP505 is hermetically sealed and weighs less than 7.5 lbs. Solid state-magnetic pulse generator systems are available in ranges from .1 to 10 megawatts, with repetition rates as high as 10,000 pps.

For complete information on the entire pulser series, write for Data File MP1100.



MAGNETIC RESEARCH CORP.
Pacing the Industry in Astro-Magnetics
60 WEST EL SEGUNDO BOULEVARD
HAWTHORNE, CALIFORNIA

Write in No. 171 on Reader Service Card
January 1960

PRODUCT PREVIEW

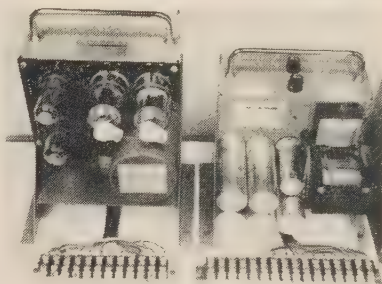
ACTUATION SYSTEM has no gear train

Gear trains and levers have been eliminated from an aerodynamic surface control system designed for in-atmosphere missiles by Bendix Products Div., Bendix Aviation Corp., S/A, South Bend 20, Ind. All differential action is obtained within the system's actuators, which can be designed for various loads and travel.

The lightweight, reliable and low-cost system includes two three-position actuators, solid propellant, and igniter. One such system weighs five lbs. and exerts 50 in.-lbs of surface force.

Write in No. 247 on Reader Service Card

SERVO AMPLIFIER accepts low signals



This electronic servo amplifier and power supply controls a wide range of ac servo motors with mechanical power outputs up to 10 watts. It will accept low level ac signals from a variety of existing transducers and from an ac feedback tachometer, says Seneca Falls Machine Co., Dept. S/A, 19 Fyfe Bldg., Seneca Falls, N. Y. The output power is available at various impedance levels via a combined matching and isolation transformer.

The power supply converts an ac input voltage to the filament and dc voltages needed to operate the electronic amplifier.

Write in No. 248 on Reader Service Card

MICROWAVE FILTER has automatic tuning

A bandpass filter for X-band application has been designed with an automatic tuning feature and a manual tuning range of 1000 mc in X-band. A push-button, 26-V dc motor allows automatic setting of the filter to F_0 , $F_0 + 3$ mc, and $F_0 - 3$ mc, says Frequency Standards, Inc., Dept. S/A, P.O. Box 504, Asbury Park, N.J.

Insertion loss is 2.5 db maximum, and VSWR is 1.5 maximum. The configuration of the resonant cavity is cylindrical. The unit is a four-section resonator.

Write in No. 249 on Reader Service Card
more on page 270

SELECTIVE PLATING

with the
**DALIC
PROCESS**



Precision-plating a roller.

FOR QUICK PRECISION PLATING

- 1 Building-up worn or over-machined parts to exact size.
- 2 Plating isolated sections—saves extensive masking.
- 3 Fitting bearings to close tolerances.
- 4 Selective stopping-off prior to carburizing or nitriding.

No Immersion Tanks, Mobile Equipment.

With a Dalic power pack, plating tools and solutions you can plate many jobs quicker at lower cost than with stopping-off and bath plating. Deposits accurately controlled. Use anywhere in your shop.

Dalic Plating Solutions

Bismuth, Brass, Cadmium, Chromium, Cobalt, Copper, Iron, Lead, Nickel, Tin, Zinc, Gallium, Gold, Indium, Palladium, Platinum, Rhodium, Silver, and alloys.

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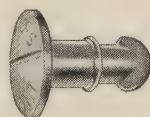
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For quick access and closure . . .

LION $\frac{1}{4}$ TURN OPEN $\frac{1}{4}$ TURN CLOSED FASTENERS



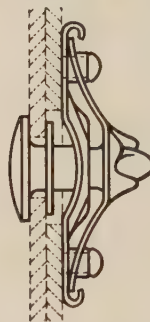
NO. 5 STUD



RETAINER



RECEPTACLE



Hinged and completely removable panels are secured reliably by unique Lion Fasteners which are opened or closed by a quick $\frac{1}{4}$ turn. These mil spec (MIL-F 5591A-ASG) fasteners have a high strength to weight ratio, lock smoothly with a positive grip, withstand vibration.

ALIGNMENT NOT CRITICAL

Both stud and receptacle "float" to accommodate misalignment. The hole, which retains the stud, is twice as large as the stud cross-section. This permits a float of .070 in all directions. The leaf spring receptacle also floats to accommodate stud positions.

WIDE VARIATIONS IN STACK HEIGHT

Total sheet thickness may vary as much as +.035 or -.015 without affecting operation. A Lion stud, specified for .160 total thickness, for example, will accommodate any stack height between .195 and .145.

SWAGED-NOSE STUD

Extra strength and smooth operation are made possible by the swaged-nose

design. All the metal in the stud goes to work. There are no thin crosspins, holes or milled slots to weaken the cross-section. Case hardening is further assurance of long, trouble-free service.

WIDE VARIETY

Lion Fasteners are available in 3 sizes—No. 5, No. 2, and Miniature. An assortment of head styles is supplied—oval, flush, wing, ring, notched or knurled—according to individual requirements.

FREE! FASTENER HANDBOOK



Send for your free copy of Southco Fastener Handbook No. 9. Gives complete engineering data on Lion Fasteners and other special fasteners. Write to Southco Division, South Chester Corporation, 253 Industrial Highway, Lester, Pennsylvania.

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MISSILES



CIVILIAN



MILITARY



COMMERCIAL

LION *Aviation* FASTENERS

one of the



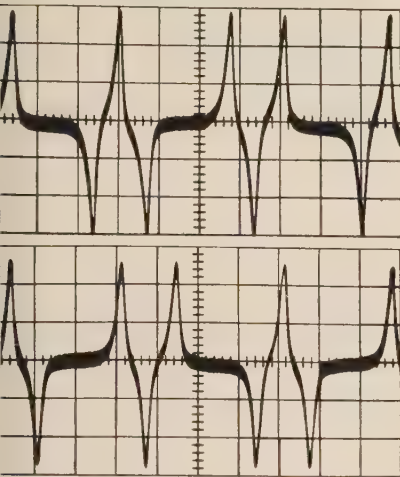
Write in No. 173 on Reader Service Card at start of Product Preview Section

SPACE/AERONAUTICS

Materials Memo

3M reports on sandwich-type magnetic tape... heat reactive tubing... sound-deadening pressure-sensitive tape

A LONG-PLAYING "RECORD"



BACK wave patterns show standard, open oxide tape (top) and sandwich tape (bottom) output characteristics.

Not Bach or Beethoven—it's a different kind of record we're proud to tell you about. It's the news that over 50,000 successive passes through a tape transport (digital or analog) are now possible with the new "SCOTCH" Brand sandwich-type magnetic tape. If you've never bothered to count the number of passes you've been getting, using conventional magnetic tapes, we'll save you the trouble. Sandwich tape offers you 10 times the life of these older constructions. What's more, the economies don't end there. You'll find that costly recording head maintenance and replacement is drastically reduced. And don't sell short the fringe benefits of no oxide rub-off or head build-up. In language that really counts, this means you can avoid the irritating chore of head cleaning after every run. Among those fortunates already using sandwich tape, there have been cases where fewer drop-outs were noted on each successive pass. On running this down, it was found that these have been due to contamination on the heads which was gradually being removed by the tape!

We won't leave you in the dark as to how all this can be possible. The key is the unique sandwich construction. It starts out with the familiar tough polyester base and the high-potency oxide magnetic coating characteristic of 3M's conventional instrumentation tapes. But here's the difference: bonded over the surface of the oxide coating is an extremely thin protective plastic layer. The oxide then sandwiched between the two films, has no choice but to stay put for prolonged reliable service. Furthermore, the ultra-smooth protective layer lets the tape glide over the head like a wet skate. While this fifty micro-inch separa-

tion between oxide and head causes a slight reduction in the high frequency or short wave length response, the medium and long wave length responses are essentially unaffected. Sandwich tape comes highly recommended for digital recording, where you can cram up to 500 pulses per inch. It's tops for most AM, FM and PDM applications, as well.

For those of you who'd like up to 50% more recording time per reel, there's a version with a thinner 1 mil base available. Your local MAGNETIC PRODUCTS representative, or the coupon, will bring more facts.

CONFIDENTIALLY, IT SHRINKS!



Unlike a "Sanforized" shirt, our IRVINGTON DIVISION's new heat reactive plastic tubing is guaranteed to shrink. This unique electrical insulation actually shrinks up to 30% in diameter when exposed for a few minutes to either a radiant heat source or circulating hot air. For example, using a temperature of 300° F, the operation is complete in 4 to 8 minutes. No inflammable or toxic dilating agents are needed. And all the initial flexibility and electrical qualities of this vinyl tubing are retained after contraction. Furthermore, it can provide a tight, smooth, abrasion and chemical resistant insulating cover over even somewhat irregularly shaped objects—like the well-protected pencil on the left.

"SCOTCHTITE" Brand heat reactive tubing is not without its share of credentials. It's approved under military specifications MIL-I-631C, as well as receiving acceptance by Underwriters' Laboratories as a 105° C electrical insulation. The cold brittle point is -20°C, which gives you a fairly healthy operating range. With a 0.016" wall, electric strength is 1000 volts per mil; 3200 psi tensile strength assures you of rugged dependable service. Available sizes range from 1/2" to 2 1/2" diameters after shrinking.

Applications for this product seem to be as broad as human ingenuity. It's already been used for wire harnesses, condensers, coils, ground straps, bus bars, tool handles, antennae, and dozens of other electrical applications. Why not discuss your needs with your local ELECTRICAL PRODUCTS DIVISION representative?

TRANQUILIZER FOR JITTERY BIRDS

Here's a prescription that will not only calm your nerves, but the shakes in your bird as well. It's a new series of aluminum foil tapes which are specifically designed to control the amplitude of vibration of the solid body to which they're applied. It's well known that uncontrolled vibration amplitude can cause not only annoying sound levels but also structural fatigue. If you're trying to lick either of these vibration problems, these tapes may be your answer. With them you could even make a mandarin's gong vibrate like a slab of lead.

There's nothing greatly mysterious about how they work. Basically, there are two principles involved. First, the added mass on the vibrating panel changes its natural frequency and reduces its vibrating amplitude.

The other principle is much more subtle in that the tape's adhesive dissipates vibrational energies. This is done by converting them to a mechanical shearing action within the visco-elastic adhesive. Presto, the vibration decay rate is improved by an important degree. As you may know, this is a relatively new but established concept.

The #428 tape series is available with 5 1/2, 8, or 12 mil backings. All offer an exceptionally high degree of vibration control per unit weight. They also have good solvent resistance and work well over a range of temperatures.

If vibration within an airframe or instrumentation compartment (to cite just a couple of instances) is a problem with you, let our INDUSTRIAL TAPE DIVISION help you put a damper on it.

FOR MORE INFORMATION...Clip and Mail Today!

Missile Industry Liaison, Dept. VAA-10
3M Co., 900 Bush Avenue, St. Paul 6, Minn.

Please send information on items checked:

- ☐ Sandwich-type Magnetic Tape ☐ Heat Reactive Tubing
☐ Vibration-damping Tape ☐ 3M Products and Capabilities for the Missile Industry

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"SCOTCH", "SCOTCHTITE" AND "IRVINGTON" ARE REGISTERED TRADEMARKS OF 3M CO.

MINNESOTA MINING AND MANUFACTURING COMPANY

... WHERE RESEARCH IS THE KEY TO TOMORROW



MISSILE
INDUSTRY
LIAISON



Write in No. 174 on Reader Service Card at start of Product Preview Section

VALVES of stainless steel



The Type 26, Models A and B, back pressure valves, now being used in missile hydraulic test carts to simulate missile system back pressure, are designed for use with petroleum base and hydro-carbon fluids, synthetic oils, and a variety of corrosive liquids, says Cox Instruments Div., George L. Nankervis Co., Dept. S/A, 15300 Fullerton Ave., Detroit 27, Mich. The stainless steel valves maintain a constant hydraulic back pressure in an upstream system by opening and relieving at the pressure for which they are set.

Pressure control is held within ± 0.1 psi over a 10:1 flow range, and total flow of both valves is 0.5 to 20 gpm. Both valves are angle-style diaphragm types.

Write in No. 250 on Reader Service Card

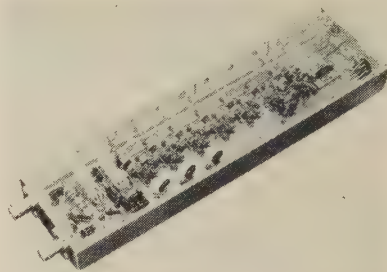
CARBIDES improve wear resistance

Two carbide compositions that are useful for corrosion-wear parts are being made by Kennametal, Inc., Dept. S/A, Latrobe, Pa. Grade K601, a binderless carbide of tantalum and tungsten, has the wear resistance of a higher priced composition, although slightly less corrosion resistance.

It has been used in seal rings and is under test in other devices, such as valves and orifice parts. Its non-magnetic properties suit it for use in wear parts for magnetic wire and tape applications. Grade K701, a tungsten carbide with chrome-cobalt binder, is more corrosion resistant than conventional carbides and it is under test in nozzles, valve balls and seats, and other parts.

Write in No. 251 on Reader Service Card

TRANSISTOR IF AMPLIFIER is low noise hybrid unit



Series 80 transistorized IF amplifier is a low noise hybrid unit combining the low noise properties of a tube input circuit with the low power requirements and ruggedness of transistors, says L E L Inc., Dept S/A, 380 Oak St., Copraque, N.Y.

Typical electrical specifications are as follows: center frequency 30 or 60 mcps; bandwidths available from one to 20 mcps; gain 100 db; and noise figures as low as 1 db.

Write in No. 252 on Reader Service Card

Robertshaw

sets the pace with

CUSTOM-ENGINEERED

MINIATURE

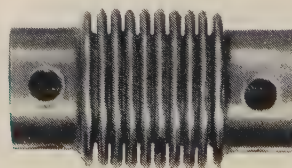
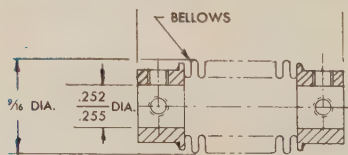
CONTROL

COMPONENTS

Write in No. 175 on Reader Service Card →

FLEXIBLE COUPLING

ELIMINATE BACKLASH, END-PLAY! ABSORB VIBRATION, SHOCK WITH ROBERTSHAW FLEXIBLE COUPLINGS



Servomechanisms, instruments and similar drive and control systems are the big users of these small, flexible units. Ideal for guarding against misalignment friction and bearing wear problems. Save space and weight. Cut down noise. Simplified design utilizes seamless metallic bellows, in choice of several metals, connected to two hubs. Sizes from $\frac{15}{32}$ " O.D. Stock sizes accommodate shafts from $\frac{1}{8}$ " to $\frac{1}{2}$ ". Other sizes custom-engineered. WRITE FOR DATA SHEET 6-801

SHOCK MOUNTS

for small electronic units

Types HTO-1 and HTO-2 Broad temperature Range, Elastomeric Mountings have load capacities of 1 and 2 lb respectively while weighing only 1 oz, says Lord Mfg. Co., Dept. S/A, Erie, Pa.

The units operate from -65 deg F to +300 deg F. Features include extreme environmental resistance, altitude protection, isolation of frequencies to 2000 cps and high internal damping.

Write in No. 253 on Reader Service Card

COAXIAL TERMINATIONS

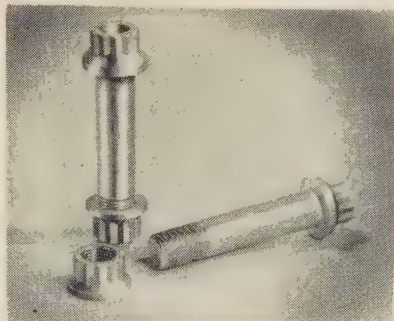
for temperature extremes

These coaxial line terminations permit proper function of the units with temperature extremes of -450 deg F to +440 deg F. Resistive elements are made of thin platinum films fired at high temperatures on ceramic forms and treated with a protective coating of silicone varnish, says Stoddart Aircraft Radio Co., Inc., Dept. S/A, 6644 Santa Monica Blvd., Hollywood 38, Calif.

Write in No. 254 on Reader Service Card

FASTENERS

for aircraft



These high-strength structural aircraft fasteners having 220,000-lb sq in muscles in 180,000 psi bodies, will permit significant weight savings on present as well as new design aircraft and missiles, according to Standard Pressed Steel Co., Dept. S/A, Jenkintown, Pa. The bolts are designated LWB 22. The featherweight self-locking companion nuts are FN 22 series.

Since the new threaded joints can be substituted size for size for existing fasteners, it is said that immediate weight savings are possible on present designs.

Write in No. 255 on Reader Service Card

VHF AMPLIFIER

has five-kw output

The developmental model of a VHF airborne amplifier that weighs less than 200 lbs and requires under three cu ft of space has been announced by Martin Co., Dept. S/A, Baltimore 3, Md. The miniaturized unit, a two-stage design, is a modified Eimac 3W 5000 A3 triode driven by a modified Eimac 4Cx300A ceramic tetrode.

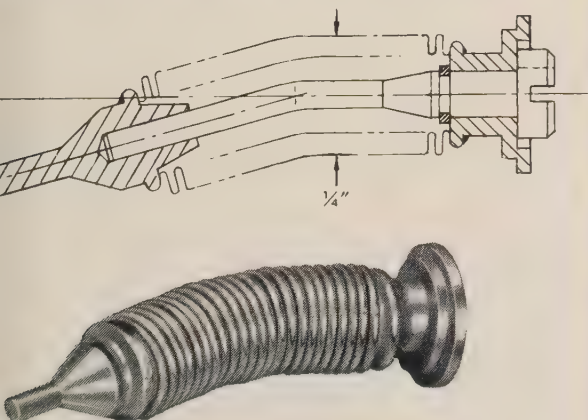
The design uses evaporative cooling, in which component heat is conducted directly into water. The boiling water that results acts as a coolant through vaporization and the release of steam. Grounded anode circuits permit immersion of the tube plates directly in the water, and a closed heat exchanger system takes care of components which cannot be immersed directly. The unit can operate over a range of minus ten to +110 deg F and at an equivalent altitude of 10,000 ft. Expectations are that minor modifications will double output while permitting about the same space and weight characteristics to be retained.

Write in No. 256 on Reader Service Card

more on next page

MINIATURE BELLOWS

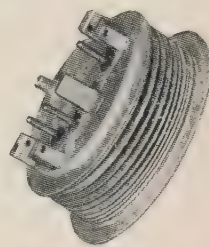
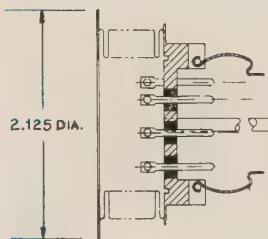
SAVE SPACE AND WEIGHT WITH RUGGED, MINIATURE ROBERTSHAW METALLIC BELLOWS



less metallic bellows only 1/4" and 5/16" O.D. for further miniaturization in aircraft, missiles, instruments and other equipment. Available in a wide range of bellows metals to provide the desired strength and performance characteristics. Sensitive to temperature and pressure changes. Custom-engineered... but available in any quantity you need. Proved in dozens of miniaturized assemblies. WRITE FOR BULLETIN G-101

FLUID EXPANSION CAPSULE

THERMAL EXPANSION OF OIL CONTROLLED BY SPACE-SAVING ROBERTSHAW FORMSET® BELLOWS

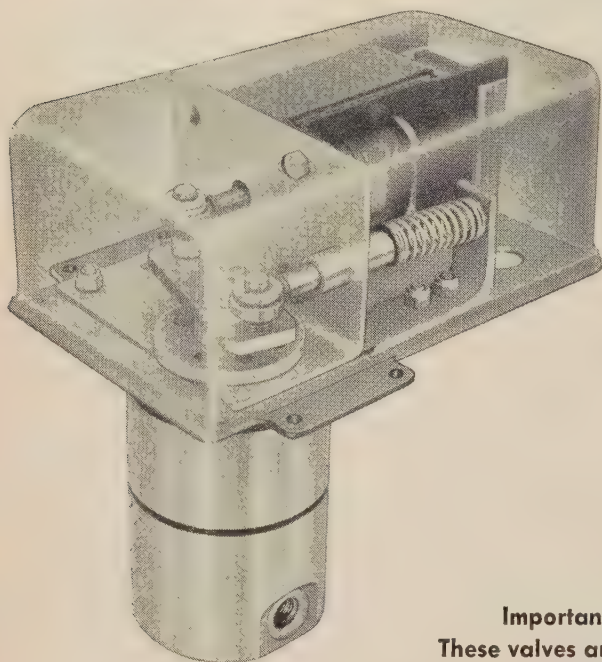


A low spring rate and a large stroke per unit of length, provided by a special Robertshaw Metallic Bellows called Formset, made possible this expansion capsule used in airborne gyroscopes. This assembly absorbs the thermal expansion of the oil which encases the gyroscope. Low spring rate in the bellows permits low pressure in the gyro. Space savings of up to 90% in bellows length can be achieved with Formset Bellows. Custom-engineered for instruments, transformers, relays and other applications using any fluid. WRITE FOR ENGINEERING DATA SHEET G-101

Robertshaw 

BRIDGEPORT
THERMOSTAT DIVISION
Milford, Conn.

10,000 P.S.I. SOLENOID VALVES



Important:
These valves are
standard catalog items.

- They are available for immediate delivery (in stock) at standard valve prices, for a service which generally requires costly (made-to-order) special valves.

- Shut off and 4-way valves in $\frac{1}{4}$, $\frac{3}{8}$ and $\frac{1}{2}$ inch port sizes are rated for 10,000 P.S.I. liquid or gases. They will withstand surges of up to 15,000 P.S.I. without damage to the valves' sealing qualities (designed for a burst pressure of 30,000 P.S.I.).

Solenoids are available for 115, 230 and 460 volt A.C. operation.

- Long maintenance-free service is achieved through the leak-proof "Shear-Seal" design. Optically flat metal to metal sealing surfaces (of the self-aligning sealing rings and the mating rotor face) are protected by staying in constant intimate contact: flow is always through the center of the "Shear-Seals," never across sealing surfaces. Sealing qualities actually improve as the seals lap themselves to a more perfect fit with each valve operation. There is no external shaft leakage because the pressure is confined to the flow passages.

For complete data write
for catalog S-10000.



CONTROL VALVE DIVISION

Barksdale valves

5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

Write in No. 176 on Reader Service Card

PRODUCT PREVIEW

SSB ADAPTER increases power ratings

The Model SSB-58-1A adapter system is the first practical solution to high- and super-power single sideband communications, says Kahn Research Laboratories, Inc., Dept. S/A, 22 Pine St., Freeport, N.Y. The design also permits standard high-frequency, high-level AM transmitters to be converted to SSB operations without engineering modifications.

Principle advantages of the system include: greater undistorted sideband rejection; less sensitivity to overloads and tuning errors; and lower tube and equipment costs. The system is designed for high frequency voice, facsimile and multi-channel FSK teletype operation from ten kw to one mw. Adapted transmitters develop a sideband power four times the normal AM carrier rating. Adapter and transmitter cover a range of from one to 30 mc.

Write in No. 257 on Reader Service Card

RUBBER COMPOUND is fuel-resistant

Seals, gaskets, cushion clamp material and diaphragms for use in the aircraft, missile and hydraulic fields are among the products which can be molded or extruded from this high-modulus, fuel-resistant fluorosilicone rubber compound, says Hadbar, Inc., Dept. S/A, 9530 Gridley St., Rosemead, Calif. The compound maintains excellent physical properties over a temperature range of -65 to $+450$ deg F, and it retains low temperature flexibility even after long periods of immersion in fuels.

Shore hardness ranges from 60 to 80, and the material shows great resistance to a wide variety of aromatic solvents as well as fuels. It is not affected by ozone and weather.

Write in No. 258 on Reader Service Card

RELAY offers load protection

The B-145 Series of relays has been designed for custom-built load protection, according to Hartman Electrical Mfg. Co., Dept. S/A, Mansfield, O. A typical unit in the series provides time delay overload protection and also signals the motor contactor at the first sign of trouble.

Inverse time delay allows for starting inrush and transients, but quickly senses locked rotor, overloads, and winding-to-winding or turn-to-turn faults. Time delays can be designed for fixed or integrated periods. The B-145 load protectors are available for currents of five amps and over, 115 to 140 V, and 60 to 400 cycles and over. They range from a small, integral, spst, two-amp control relay to a heavy-duty ac transfer contactor.

Write in No. 259 on Reader Service Card

DUPLEXER for high power radars

The inherent fast recovery and low insertion loss advantages of non-reciprocal differential phase shift ferrite circulator have been attained in a lightweight ferrite duplexer developed for high power radars in the 16 to 17-kmc range, says Microwave Associates, Inc., Dept. S/A, Burlington, Mass. The MA-122TS assures crystal protection independent of transmitter power and antenna mismatch, and its electrical ratings hold for the -55 to -125 deg C range. Length ($7\frac{1}{2}$ n.) and weight (15.5 oz) make the duplexer particularly suitable for airborne radar use. Specifications include a recovery time of under two usec, VSWR of 1.15 Maximum, and peak and average power of 150 kw and 150 W. Similar ratings apply to the MA-122ATS, which is available for the 15.5 to 17.5-kmc band.

Write in No. 260 on Reader Service Card

more on page 276

FREE COATED FABRICS MANUAL



Handy, 12-page, fully illustrated booklet describes in detail all basic specifications, properties, uses and performance characteristics for "Fairprene"* coated fabrics and cements.

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Fabrics Division
Wilmington 98, Delaware**

*Fairprene" is Du Pont's registered trademark
on coated fabrics, sheet stocks and cements.

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INDUSTRIAL COATED
FABRICS**



Better Things for Better Living . . . through Chemistry

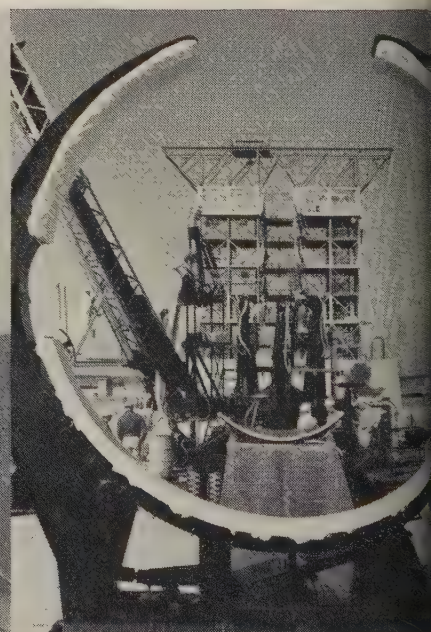
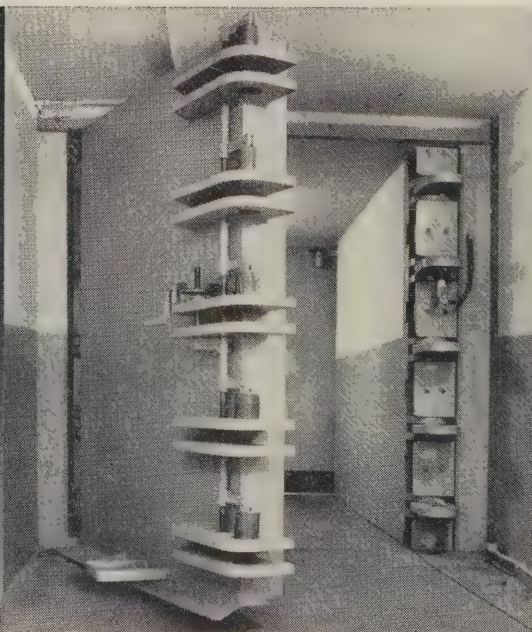
**E. I. du Pont de Nemours & Co. (Inc.)
Fabrics Division, SA-01, Wilmington 98, Delaware**

Please send me free copy of Du Pont's guide to coated fabrics for industry.

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Write in No. 177 on Reader Service Card at start of Product Preview Section

About the earthly side of Canaveral—Only recently, it spawned little more than snakes and other crawling creatures. Today, high flying birds are poised there, and because they can't jump off from sand, most of the Canaveral manpower and materials go into ground support equipment. And virtually all the steels required can be purchased from a single source—United States Steel. Whether we're talking about carbon steel, high-strength low-alloy steel, constructional alloy steel, or stainless steel, steel fence, electrical cable, wire rope or cement,



On this vertical oscillating radar tracking unit, every nut, bolt, and insulator collar is Stainless Steel. To the right, is a Stainless Steel fuel tank, and beyond that rises the U. S. Air Force Thor gantry tower, with a structural steel frame similar to a nine-story building.

The door to the U. S. Air Force Atlas blockhouse weighs 24 tons. It is solid manganese steel about eight inches thick. At X minus 15, the door automatically locks and it is blast-proof and vapor-proof.

The mobile transporter for the Thor is strong but light on its wheels because it was designed with weight-saving high-strength steels. Slanting to the left is the steel umbilical tower which carries Stainless Steel fuel lines and control lines.

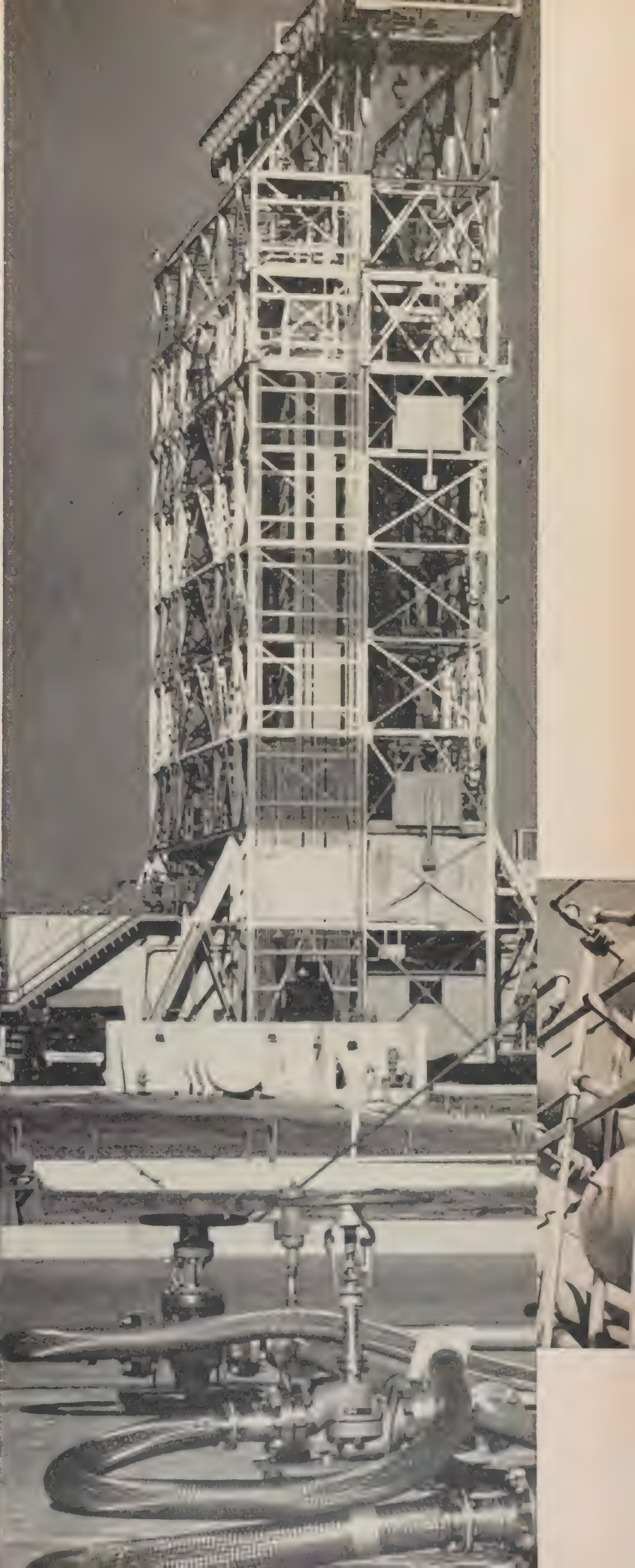
United States Steel maintains
technical services to provide
proper assistance to cope
with any problem on these
materials for ground support.
When a ground support pro-
gram is still on the drawing
board, consult

USS United States Steel
USS is a registered trademark



Pressure vessels for the U. S. Air Force Bomarc A system
are stainless steel cylinders about 20 inches in diameter and 26½
feet long. The cylinder walls are slightly more than an inch-and-a-half
thick and will contain gas at pressure up to 4500 psi.

Steel pipes and Stainless Steel flexible tubing carry the
fuel to the Thor complex. Fuel lines must be almost surgically clean
to prevent explosions and assure proper flow. Inspectors check the
lines everything from microscopes to ultraviolet lamps. ▶





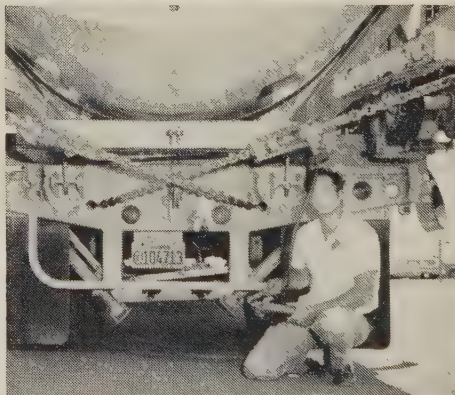
AT DOUGLAS AIRCRAFT COMPANY

Aeroquip Tie-Downs Solve A Missile Transport Problem

Heavy-duty tie-downs that operate easily were needed to secure Douglas THOR missiles to special transporting trailers. Aeroquip solved the problem by designing hydraulically tensioned chain tie-downs that are rated at 13 tons strength, yet weigh only 27 lbs. each.

These tie-downs are but one of the many types of web, cable and chain tie-down systems developed by Aeroquip's General Logistics Division, in rated strength from 150 lbs. to 60,000 lbs.

If you have a fabricating or transporting problem requiring any type tie-downs, let Aeroquip help you. Mail the coupon below for Bulletin 358.



This Aeroquip Chain Tie-Down is tensioned hydraulically to secure the missile to the trailer bed. It requires no wrenches to attach, provides a 3" take-up.

Aeroquip

GENERAL LOGISTICS DIVISION

2929 FLOYD STREET, BURBANK, CALIFORNIA

SA-1

Please send me a copy of Bulletin 358 on Aeroquip Tie-Downs.

Name _____ Title _____

Company _____

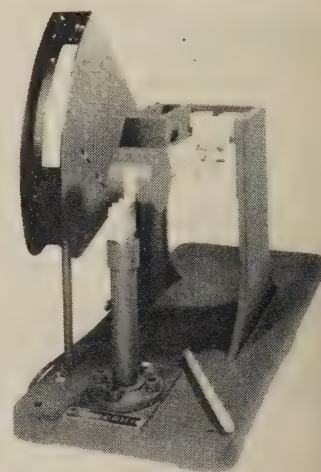
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City _____ Zone _____ State _____

Write in No. 179 on Reader Service Card at start of Product Preview Section

PRODUCT PREVIEW

TEAR TESTER measures strength



This heavy duty torsion tear tester measures tearing strength of strongly directional materials which tend to tear at an angle from the application of force. The tester holds the specimen rigidly throughout its entire length on both sides, and the tearing force is directed to produce a tear down the center line, says Thwing-Albert Instrument Co., Dept. S/A, Penn. St. and Pulaski Ave., Philadelphia 44, Pa.

It is said to be ideal for cylinder board, corrugated board, glass fiber, reinforced gummed shipping tape, vinyl and rubber sheeting, gauze and other woven fabrics.

Write in No. 261 on Reader Service Card

POTENTIOMETER is versatile

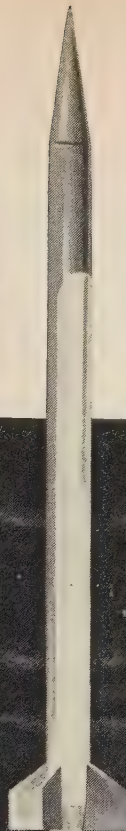
Temperature, pressure, stress, flow or acceleration signals from thermocouples or other transducers used in flight test programs are converted into direct-reading indications by the Autopot Series EMP-NS2 self-balancing potentiometer. Simple conversion of the basic model for either millivoltmeter or pyrometer applications has been achieved through plug-in construction, says Daystrom Pacific, Dept. S/A, 9320 Lincoln Blvd., Los Angeles 45, Calif.

The versatile, miniature unit is available in 39 standard models, which include pyrometers in 25 standard ranges, and millivoltmeters in 14 standard ranges. A new servo design makes operation completely automatic and ambient temperature compensation is also automatic to maintain accuracy under varying conditions. Minimum readable input charge is 30 μ V, and the power requirement is 0.15 amps, average, at 115 V, 400 cps.

Write in No. 262 on Reader Service Card

more on page 278

NOW OPERATIONAL:



**Weather-sounding
rockets carrying
R/M Pyrotex®
motor-tube liners**

There's no question whether plastics will work on high-temperature rocket and missile parts. R/M asbestos-phenolic materials are working regularly now in space-vehicle applications where their remarkable combination of properties has proved their value.

Take this example: We're supplying completely fabricated *wrapped tubes* of R/M Pyrotex phenolic-impregnated asbestos tape as motor-tube liners for weather-sounding rockets. These liners withstand a direct rocket blast for periods up to 90 seconds. Their combination of high ablation-resistance, good thermal insulating properties, and high strength-to-weight ratio makes the

choice of R/M Pyrotex materials clear for this high-temperature application. The extra-long spinning-grade asbestos fibers used in all R/M high-temperature reinforced plastics contribute great physical strength to these liners, as they do to nozzles, exit cones, fins, nose cones, etc.

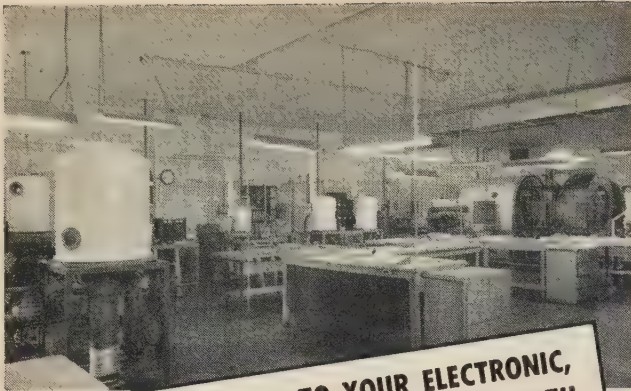
Test R/M materials without tooling costs. We can supply your testing program with molded billets or tubes from which you can machine prototype parts at the cost of the materials alone — *no charge for tooling*. What better way to learn the merits of an exciting new material? Phone, wire or write your requirements.



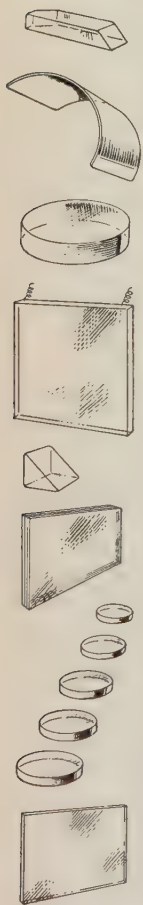
RAYBESTOS-MANHATTAN, INC.

Reinforced Plastics Department, Manheim, Pa.

SPECIALISTS IN ASBESTOS, RUBBER, ENGINEERED PLASTICS, SINTERED METAL



**FIND THE ANSWER TO YOUR ELECTRONIC,
OPTICAL AND INFRA-RED PROBLEMS WITH**
Kinney
PRECISION EVAPORATED FILMS



Have you explored the possibilities of controlling REFLECTION, TRANSMISSION, ABSORPTION and EMISSIVITY with KINNEY Precision Evaporated Films? Here are advanced techniques, backed by years of research and successful production of optical and electrical films applied to a broad range of surfaces and substances. These development and production facilities are available to you: Front and Back Surface Mirrors—any metals... Low Reflection Films—any wave length... Semi-Transparent Films... Dichroics... Beam Splitters... R.F. Shielding... Anti-Electrostatic Films.

KINNEY offers Infra-Red Reflecting Films, designed to your specifications... can be deposited upon Glass, Plastic or Metal and many other materials.

KINNEY Infra-Red Low Reflection Films provide peak transmission of desired wave length on Glass, Quartz, Germanium, Silicon, Arsenic Trisulphide and many other materials.

KINNEY provides precise deposition of films for Dark Mirrors and Beam Splitters as well as Absorbing Films.

KINNEY also provides these important Electrical Aids: Anti-Electrostatic Films... Transparent Conducting Films... Solderable Films on Glass, Phenolics, etc.

Write for information regarding your specific problems... no obligation.

VACUUM EQUIPMENT DIVISION
THE NEW YORK AIR BRAKE COMPANY
1327A ADMIRAL WILSON BLVD. - CAMDEN - N. J.

Please send copy of Bulletin No. 4900.1 describing KINNEY Precision Evaporated Films.

Name _____
Company _____
Address _____
City _____ Zone _____ State _____

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**MAIL THIS
COUPON FOR
YOUR COPY OF
BULLETIN
NO. 4900.1**

MAGNETRON
is mechanically tunable

A mechanically-tunable X-band magnetron with a 9300 to 10,000-mc range is rated at a nominal seven kw peak with peak input of 4.5 amps at six kv and .002 duty ratio, says Microwave Associates, Inc., Dept. S/A, Burlington, Mass. The unit is designed for critical, jitter-free, pulsed-doppler and moving target indicator applications.

Reduction in pulse-to-pulse AM jitter is reported to result in outstanding radar definition and the tuning drive mechanism adjusts tubes to specific frequencies without the help of spectrum analyzer or frequency meter checks. Pulse time, frequency and amplitude jitter ratings are less than 1.4 msec rms, 60 kc rms, and .02 db, respectively. The MA-218 is convection air-cooled and couples to a modified UG-40/U flange.

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TRANSDUCER
withstands acid

Precise measurements of tank, gas and line pressure can be made by this transducer and telemetered as prime readouts although the device may be in direct contact with red fuming nitric acid. The medium pressure transducer, designed for missile ground test and engine system performance checkout, is available for other military and commercial applications, according to Servonic Instruments, Inc., Dept. S/A, 640 Terminal Way, Costa Mesa, Calif.

Operating performance characteristics are maintained in the face of vibrations to 35 g's, and the device can withstand a 300-deg F temperature. Specifications include a range of zero to 50 psia, linearity of ± 0.5 per cent, and a weight of nine oz.

Write in No. 264 on Reader Service Card

PRESSURE CONTROL
for explosive areas

A sensitive, explosion-proof differential pressure control which is designed for use in areas where explosive gases or vapors are present has been announced by United Electric Controls Co., Dept. S/A, 85 School St., Watertown 72, Mass. It is also said to be useful where it is necessary to know the difference between two separate pressures or vacuums.

The control is uncalibrated and pressure settings are made by removing the cover and adjusting the hexhead adjustment screw. It weighs about 25 lbs. Switch actions include normally open, normally closed or double throw with no neutral position. Switches are single pole and suitable for ambient temperatures up to 100° F and are rated 15 or 20 amp., 115/230 vac.

Write in No. 265 on Reader Service Card

CERAMIC CONNECTORS
withstand thermal shock

This boron-free ceramic electrical connector with withstand sudden chilling from room temperature to -325 deg F and then warm water immersion without loss of vacuum seal, according to Technical Industries Corp., Dept. S/A, 389 N. Fair Oaks, Pasadena, Calif. Further, one hour at 850 deg F and immersion in room-temperature water will not cause connector failure.

Firing point of the 1200-deg connector is 1550 deg F and softening point, 1250 deg F. The connectors are also resistant to strong acids and they show no change after one hr of exposure to ammonium hydroxide. Case material is 303 stainless steel, and pin material is the same but is silver plated. Electrical resistivity (ohm-cm) is about 10^7 at 1250 deg F and 10^{12} at 600 deg F.

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more on page 281

Write in No. 182 on Reader Service Card
SPACE/AERONAUTICS

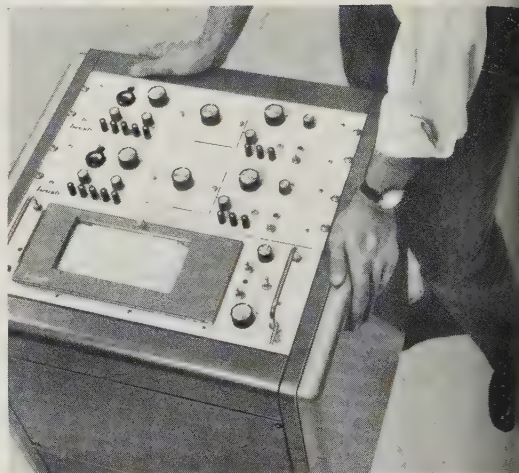
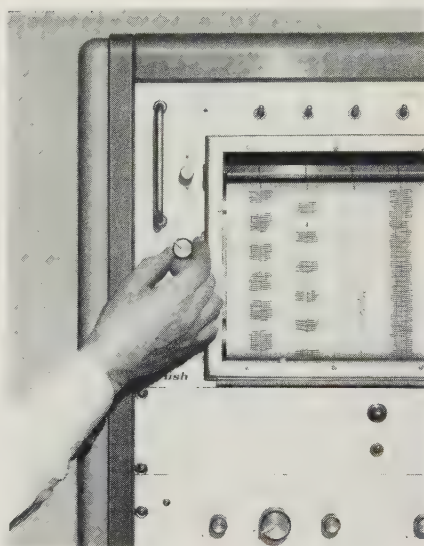
insight at 4 milliseconds

recorded with Brush operations monitors. Multiple high-speed events are reported in writing within 4 milliseconds of occurrence—to establish the basis for split-second, million dollar decisions necessary in today's complex control systems. Up to 120 separate "on-off" event signals are monitored and permanently recorded on a chart only 12" wide. Fixed-stylus electric writing provides sharp, reproducible traces of uniform clarity. Chart speeds from one to 250 mm/sec permit a precise interpretation of all events, with resolution up to 500 signal changes per second. For military or industrial analysis and control, no direct writing recording system can match the capabilities of Brush Operations Monitors. Write today for complete specifications and application data.

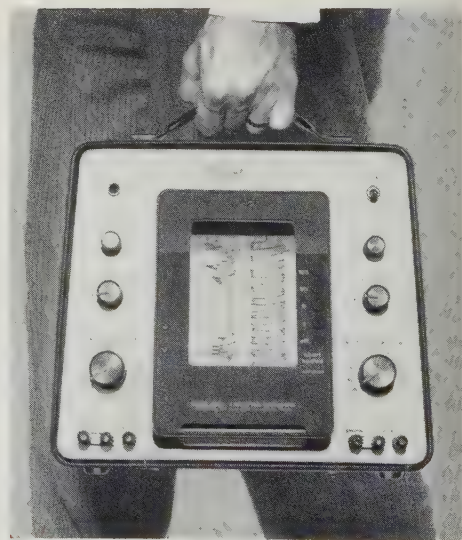




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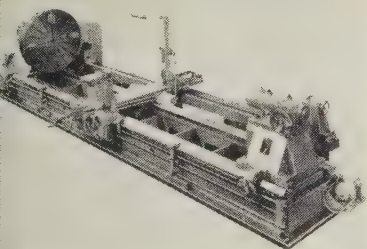
37TH AND PERKINS

CLEVITE
CORPORATION

CLEVELAND 14, OHIO

LATHE provides 72-inch swing

This new "Space-Master" series provides for swings up to 72 in and center distances ranging up to 50 ft. Among the features is a 16-spindle-speed headstock with lapped herringbone gears. Headstock bearings are precision taper roller type, says

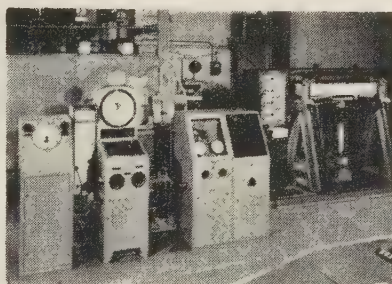


Sidney Machine Tool Co., Dept. 1/A, Sidney, O. For thread and feed changes 60 ratios are standard. For infinitely variable speeds, they are available with dc motor drive.

A power operated rapid traverse has multiple screw supports and operates in a totally enclosed housing. A safety clutch prevents damage if the carriage should run into an obstruction.

Write in No. 372 on Reader Service Card

FATIGUE MACHINE for true-to-life tests

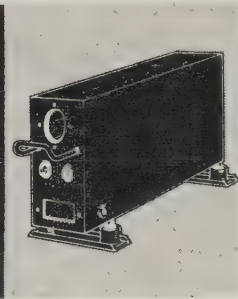
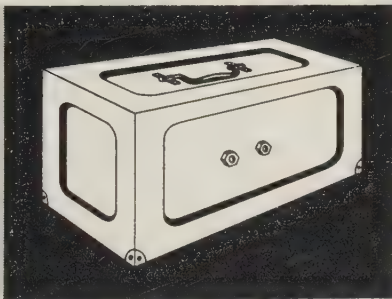


This Losenhausen-Riehle fatigue testing equipment subjects material specimens and structural assemblies to flexural stresses of varying magnitude and sequence. Results can yield valuable new data about the general behavior when subjected to loads of varying magnitude followed by rest periods or high static overloads, says American Machine and Metals, Inc., Dept. S/A, E. Moline, Ill.

Structural assemblies that can be tested include: wings, fuselages, tails, and other frame components; machinery and engine parts and assemblies; hull section of ships, girders and joints of bridges, prestressed concrete beams and built-up timbers.

Write in No. 373 on Reader Service Card
more on page 286

CIRCLE SEAL specialized RELIEF VALVES



For applications such as pilot suits, shipping containers, black boxes...

Circle Seal special relief valves provide:

- Protection against excessive pressure differentials
- Protection against moisture, dirt and contaminants
- Protection against vent port malfunction on missile solenoid valves
- Protection against electronic equipment damage
- Protection against pilot suit overpressurization

Circle Seal's many specialized valves provide "dead tight" sealing where it is required. They have been operationally proven in critical airborne applications—problem areas you may be exploring right now.

Circle Seal's engineering know-how and experience can help you find the right solution.



Write for free engineering data!
JAMES, POND & CLARK, INC.
2181 East Foothill Boulevard
Pasadena, California

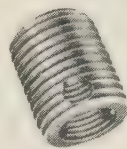
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Write in No. 380 on Reader Service Card

The quickest most practical way to put strong threads in soft materials the **TAP-LOK**[®] INSERT



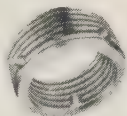
SLOTTED

IN SOFTER METALS AND PLASTICS... Has full V-form external threads to provide maximum locking torque and permit wide choice of mating hole sizes. Recommended for soft aluminum, zinc die castings, sand castings and plastics. Meets requirements of MIL-MS-35914.



H-SERIES

FOR HIGHER STRENGTH MATERIALS... Has heavy wall and truncated root external thread and three-hole cutting edges for hard-to-tap higher-strength materials and to meet MIL and other specs calling for Class 3B thread fit for gaging after installation.



P-SERIES

FOR SPARK PLUG SOCKETS... Designed to eliminate thread wear and renew damaged threads in spark plug sockets in aluminum cylinder heads. Available from stock for standard plug sizes to meet most common needs.



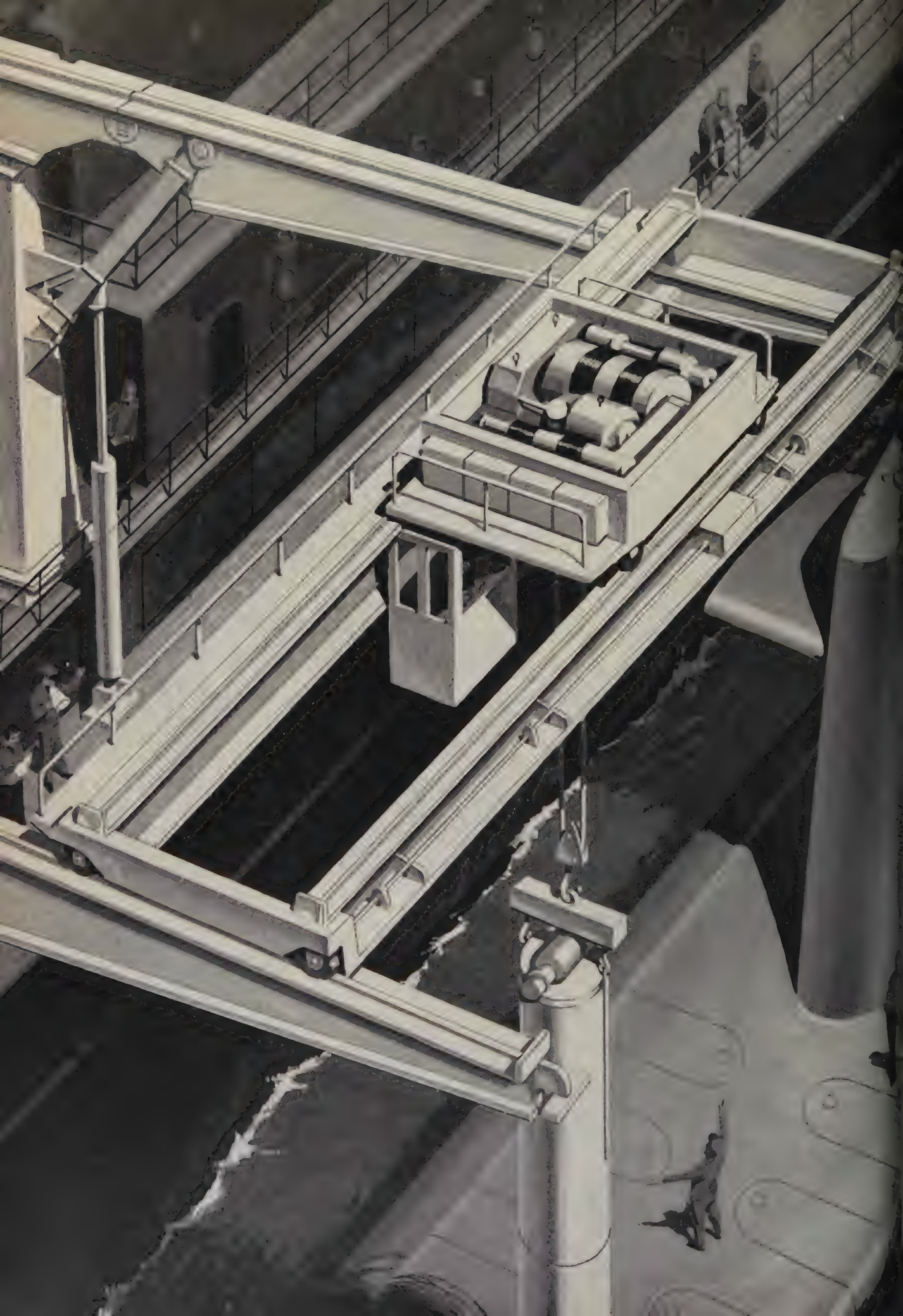
W-SERIES


FOR WOOD... Has coarse pitch external threads offering maximum strength in combination with ability to be driven into thin sections without splitting them. For furniture, cabinets and other wooden parts where strong, permanent threads are needed, or that are frequently assembled and disassembled.

Another fastener development from—

TAP-LOK  **GROOV-PIN CORPORATION**

1121 Hendricks Causeway, Ridgefield, N. J.
Write in No. 132 on Reader Service Card





Threading the needle with a POLARIS missile using Westinghouse Load-O-Matic controls

Easing POLARIS missiles from a tender into the launching silo of an atomic submarine takes a handling system that combines ruggedness with extreme maneuverability and safe, sure, precision control—control so sensitive that the POLARIS seems to float in the air as it swings smoothly and gently into position in the submarine.

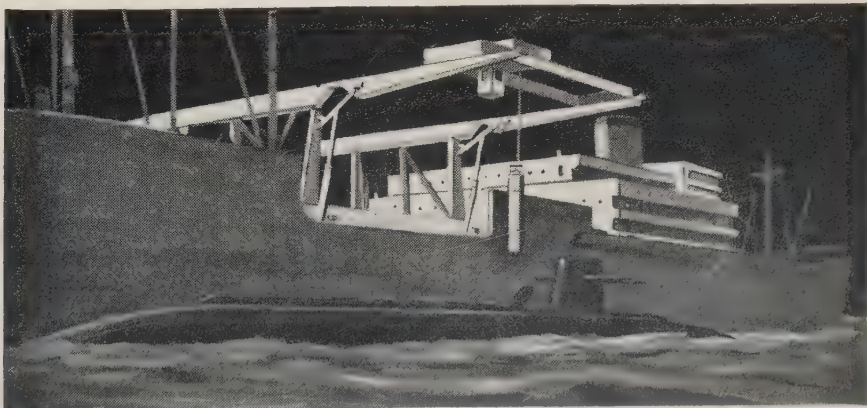
Westinghouse Load-O-Matic* crane control system was selected by Skagit Steel and Iron Works¹ for this exacting and delicate handling operation because of its unerring vernier precision performance. The combination of hoist, bridge and trolley controls operating with almost microscopic accuracy nullifies the pendulum-like swaying of the load. These positive, stepless speed controls provide movements at less than one foot *per minute*, yet will accelerate smoothly up to two feet *per second*.

The exclusive Westinghouse features which permit such precision also provide maximum reliability and minimum maintenance. Static controllers, saturable reactors and magnetic amplifiers provide stepless control and eliminate moving parts, mechanical relays and switches which corrode, wear out and require frequent maintenance. The marine-insulated a-c wound rotor motor adds additional reliability and further reduces maintenance.

Whatever your requirements for missile handling equipment—drive systems for launchers, erectors, shelters, loaders, or shockproof equipment for hardened sites—take advantage of the Westinghouse engineering knowledge, experience, range of products and unit responsibility for any type of electro-mechanical system. Contact your Westinghouse sales engineer or write: Westinghouse Electric Corporation, 3 Gateway Center, Pittsburgh 30, Pa.

YOU CAN BE SURE... IF IT'S **Westinghouse** 

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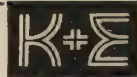


*Trade-Mark
¹Located at Sedro Wooley, Washington.

J-92031

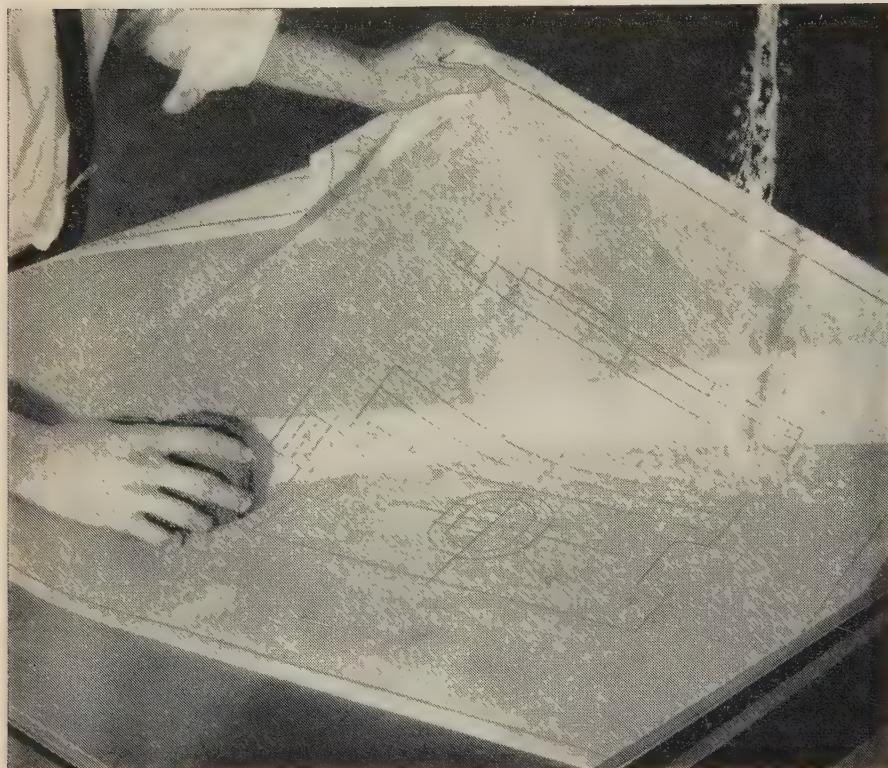
Write in No. 219 on Reader Service Card

Some Ideas



for your file of practical information on drafting
and reproduction from

KEUFFEL & ESSER CO.



This badly-soiled drawing is getting a mild soap-and-water bath to restore its original printing quality.

Tracings you can wash! Mention this to a Chief Draftsman and you'd likely see his eyes light up as he perceives the implications of a simple new technique—one that's being used now by Raytheon Co. and could save them at least \$50,000 this year. The secret: **Herculene®** Drafting Film by K&E, plus Staedtler Duralar plastic pencils—a completely washable combination, and the answer to...

A Dirty Old Problem

Functionally, an engineering drawing is only as good as the prints it will produce. This is a fact of life that governs any distribution-print system—conventional blueprints, white prints, or reduced-size prints. It holds true in a full-fledged miniaturization program, too. How long will an original tracing continue to produce top-notch prints? The answer depends on how much and what kind of handling it receives. Revisions, smudging, processing and filing all take their toll of a drawing's printability, decreasing it gradually—and sometimes quite sharply. As printing quality diminishes, some form of rehabilitation becomes necessary. But re-drawing—whether manual or photographic—can be costly and time-consuming. Drafting and reproduction experts have been wishing and work-

ing for a more efficient and economical solution.

A Simple Solution: Soap-and-Water

Washing became a possible answer with the advent of polyester-base drafting films and plastic pencils—and a practical reality with **Herculene**. This remarkable film combines a stable, waterproof Mylar® base with a completely washable surface for smudge-proof Duralar pencil lines—which bond to the **Herculene** surface and won't wash off.

Only the dirt washes away. There's no loss of line-background contrast, no loss of detail. The tracing can be restored to its original condition in a few moments—without re-drawing!

A Proved Money-Saver

To amplify an earlier point: the Missile Systems Division of Raytheon has been washing **Herculene** drawings for the past year, and now expects to save over \$50,000 on re-draws alone in the year ahead. A large aircraft manufacturer has used the **Herculene**-Duralar soap-and-water method even longer, and reports impressive dollar savings plus an outstanding improvement in print quality.

In 6 months of testing and 14 months of actual drafting-room use, Raytheon engineers exposed **Herculene** to all basic trials—and a battery of fiendishly extreme conditions. They scored **Herculene** with a sharp scribe, but couldn't remove the matte surface. They taped a sheet to the floor and had a 200 pounder roll over it in a swivel chair during an active day. **Herculene** was baked and frozen—and doused with hot coffee—with no effect on its surface. After two hours, the coffee stain was washed off without a trace. Results of these torturous tests were so favorable that now, Raytheon's Missile Systems Division uses practically no drafting film but **Herculene**!

A Note of Caution

There are other waterproof drafting films, but plastic pencil lines will wash off some of them. So, when comparing polyester-base films, it's best to check them for *pencil line washability*. And another point—don't try this technique with ink or graphite lines—use only the Duralar K1 or K2. Even if you don't want to adopt the washing technique immediately, you're free to make the change at any time if you use **Herculene**—the *indestructible* drafting medium with the washable, engineered surface.

More Merciless Testing Invited

We'd be pleased to send you a sample of **Herculene**, and we invite you to do your best to ruin its excellent drafting and printing quality. The **Herculene** sheet comes in a small folder with complete instructions and a water-fast Duralar pencil—which K&E engineers helped develop for use with washable **Herculene** Drafting Film. Mail the coupon below for your sample!

KEUFFEL & ESSER CO., Dept. AA-1 Hoboken, N. J.

Please send me further information about the washable tracing method, plus a sample sheet of **Herculene** Drafting Film and a Duralar pencil.

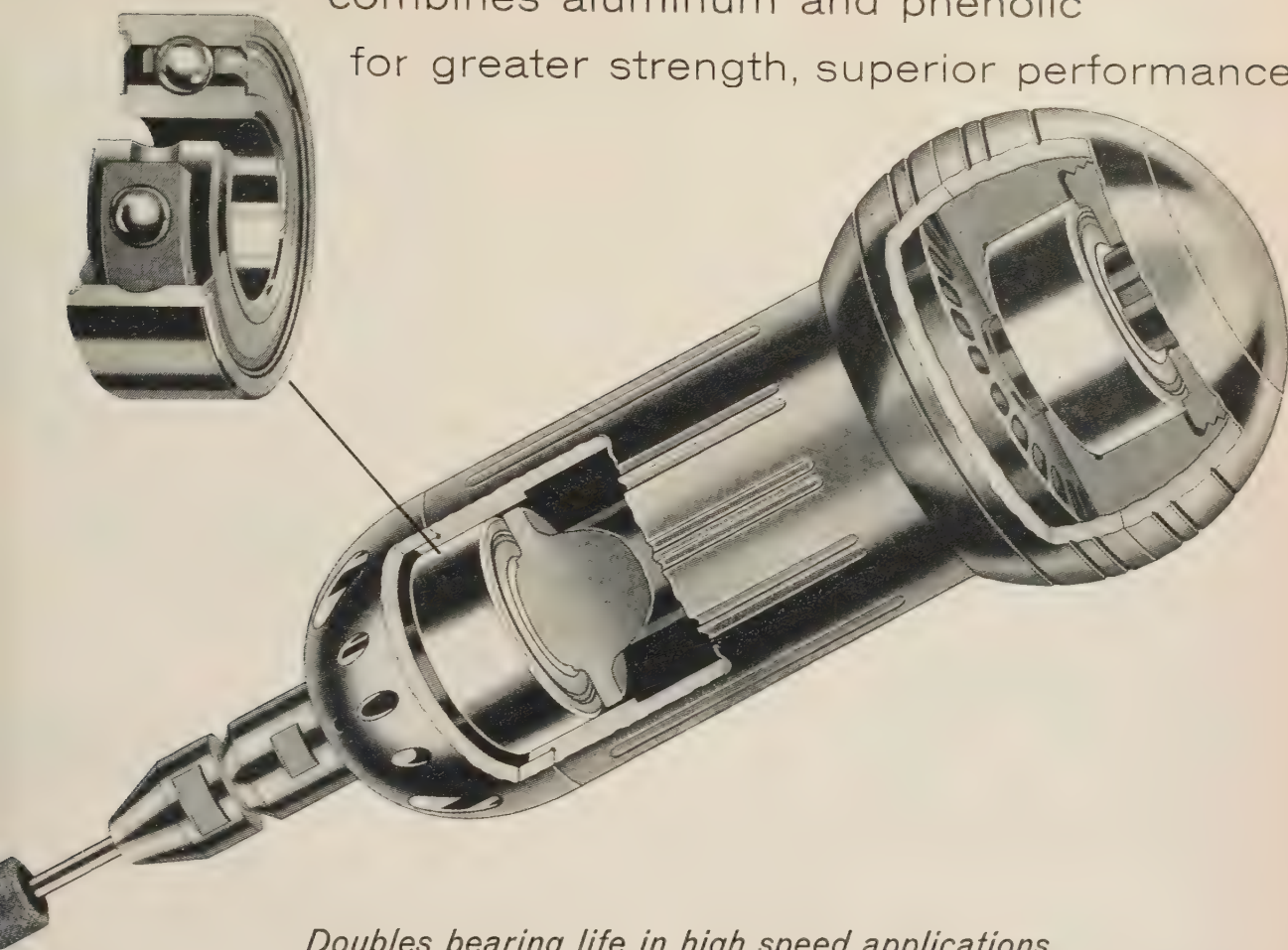
Name & Title _____

Company & Address _____

1509

Write in No. 330 on Reader Service Card at start of Product Preview Section

BARDEN "T" retainer combines aluminum and phenolic for greater strength, superior performance



Doubles bearing life in high speed applications

Power tools, gyro rotors, aircraft and missile accessories and other high speed applications require bearings that combine high load capacity and endurance at speed. To meet these exacting demands, Barden developed the "T" ball retainer which combines the advantages of phenolic with the strength of aluminum.

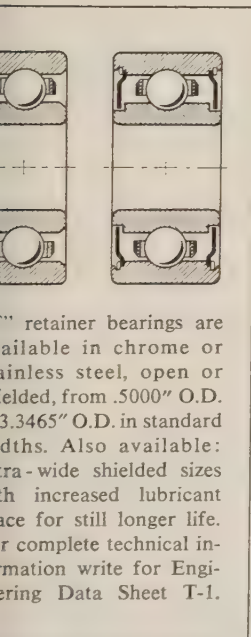
The two-piece "T" retainer has laminated phenolic center sections bonded to high-strength aluminum alloy side plates. It is securely joined by body-bound rivets tightly headed against metal at both ends. The retainer's thin cross section permits maximum exposure of balls and raceways to lubricant. Outer ring piloting provides optimum lubricant circulation.

These features, together with high load capacity, result in longer, trouble-free bearing life. For example, double shielded, grease lubricated "T" retainer bearings have operated continuously in textile spindles for more than 18,000 hours at 30,000 RPM.

Like other Barden advances in engineering and manufacturing, "T" retainer bearings solve a specific performance problem. Other Barden Precision ball bearings satisfy such extreme demands as:

- High temperatures (to above 400° F.)
- Low torque (to 10 dyne-cm. for 2 lb. load)
- High speeds (to over 300,000 RPM)
- Concentric rotation (to .00005" max. T.I.R.)

The complete Barden line includes sizes from .0469" bore to over 3" O.D., all manufactured to Barden Precision standards of dimensional accuracy, uniformity and reliability. Refer to Sweet's Product Design File (8h/Ba) for Barden catalog and bearing selection guide.



"T" retainer bearings are available in chrome or stainless steel, open or shielded, from .5000" O.D. to 3.3465" O.D. in standard widths. Also available: extra-wide shielded sizes with increased lubricant space for still longer life. For complete technical information write for Engineering Data Sheet T-1.

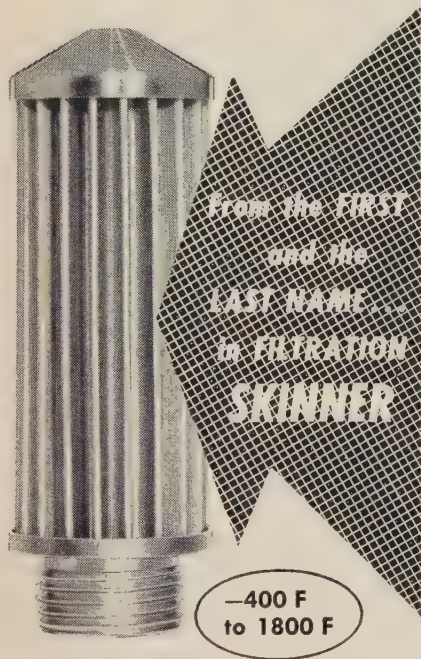
...specify

BARDEN PRECISION BALL BEARINGS

THE BARDEN CORPORATION, 220 Park Avenue, Danbury, Connecticut
Western office: 3850 Wilshire Boulevard, Los Angeles 5, California

Write in No. 183 on Reader Service Card at start of Product Preview Section

Here's a **NEW** FILTER ELEMENT that **FORBIDS** MEDIUM MIGRATION



From SKINNER — a name famous in filtration since 1927 — comes a unique, high temperature filter element for high performance aircraft and missile applications. A unique acid resistant braze and fabrication method whips the problems of acid compatibility and restricted temperature ranges. Temperature limits are from -400 F to 1800 F in continuous fluid-operating ranges. No filter medium migration. A smaller envelope is another advantage of this highly efficient element. Any type of housing applicable and delivery is immediate. If you have a filtering problem, write Skinner . . .

SKINNER FILTER

DIVISION OF



hydrodyne
CORPORATION

7350 Coldwater Canyon, No. Hollywood, Calif.
Phone: POplar 5-8001

Write in No. 184 on Reader Service Card
286

PRODUCT PREVIEW

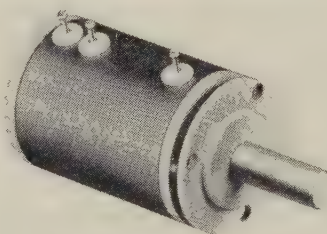
PRESSURE SWITCH is sub-miniature

This ¼ oz transistor size pressure switch is designed for surge, lead and variance detection as automatic leak detectors on missile programs, says Century Electronics & Instruments, Inc., Dept. S/A, Box 6216, Tulsa, Okla.

Other specifications include: setting limits, 1 to 100 psig; operating range, 1 to 500 psig; temperature, -65 deg F. to 250 deg F.; proof pressure, 3000 psig; burst pressure, 5000 psig; vibration, 0 to 2000 cps at 10 g.

Write in No. 267 on Reader Service Card

RANGE COMPUTER for air-to-ground missiles



The Launch Range Computer is designed to aid pilots in calculating the distance from airplane to target at any time, says Thomas A. Edison Industries, Instrument Div., Dept. S/A, 61 Alden St., West Orange, N.J.

The unit contains 2 control transformers, a servo motor, a transistor-magnetic amplifier, a gear train with slip clutch and push button reset, and an indicator and indicator light. The complete package weighs 44 oz.

Write in No. 268 on Reader Service Card

INDICATOR checks explosive systems

Any electrically-initiated explosive, propellant or pyrotechnic system can be checked for system and circuit operation with the Pyrinicator, says McCormick Selph Associates, Dept. S/A, Hollister Airport, Hollister, Calif. The indicator replaces such explosive power packages as pressure cartridges, explosive bolt cartridges, igniters or initiators in the system under test.

The indicator can establish a sensitivity that is equal to, greater, or less than that of the replaced cartridge. A red pop-out mechanical indicator in the Pyrinicator shows if circuits have operated during continuity checkout, interference tests, and circuit tests. The units cannot initiate any explosive, propellant or pyrotechnic train.

Write in No. 269 on Reader Service Card
more on page 288

MULTIROLL FILES



TRACINGS
PRINTS • SHEET MATERIAL
QUICK, FILING AND WITHDRAWAL

Depth	11¼"	22¼"	30½"	36½"	42¼"
49 Tube	49AB	49CD	4930	4936	4942
1¾" I.D.	\$7.50	\$9.50	\$12.80	\$13.80	\$14.80
MODEL					
25 Tube	25AB	25CD	2530	2536	2542
2¼" I.D.	\$7.00	\$9.00	\$11.80	\$12.80	\$13.80

Shipping Weight

Model 49 8 lbs. 12 lbs. 15 lbs. 18 lbs. 20 lbs.
Model 25 6 lbs. 10 lbs. 13 lbs. 15 lbs. 17 lbs.
ENAMELED DARK GREEN OR MED. GRAY - State Color



JR 36
Designed to Mount Under Board—Mounting Brackets Furnished. Gray Only.

Sold in Sets Only—
2 JR36 Per Set

• **SOLD DIRECT ONLY** Write to Dept. BP
F.O.B. St. Clair Shores, Mich. • PRescott 3-2515

9.50
SET OF TWO

8 lbs. ship. wt.

ROLL & FILE SYSTEMS, INC. P.O. BOX 3863 B
DETROIT 5, MICH

Write in No. 185 on Reader Service Card

Only **ONE** Torque
Wrench can be
accurately used
with . . .

**EXTENSIONS AND
ADAPTERS**

It is mechanically impossible to use any Torque Wrench with adapters or extensions (with accuracy) unless that Torque Wrench has a positive, built-in, fixed load position.

This essential factor of accuracy, misunderstood or ignored in the design and manufacture of some torque tools, can completely defeat their purpose.

Patented
pivoted handle
fixes load position

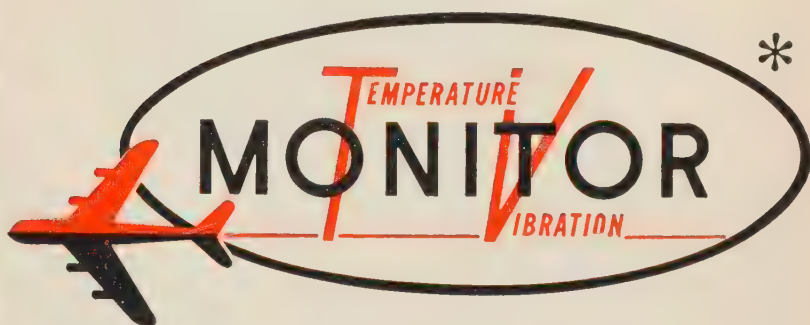
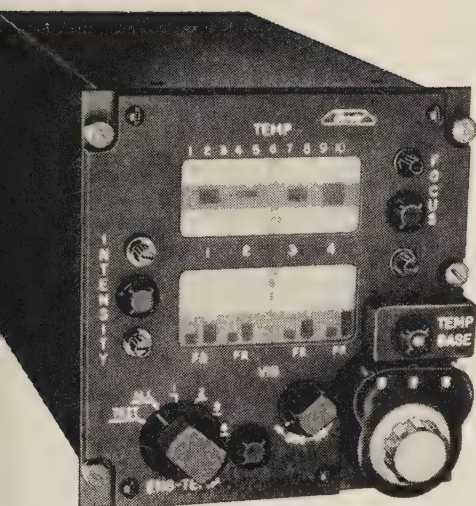


Write for **Torque Manual**
with formulae tables and explanations for correct use of adapters and extensions.

P.A. **STURTEVANT CO.**
ADDISON QUALITY ILLINOIS

Write in No. 186 on Reader Service Card
SPACE/AERONAUTICS

ANNOUNCING A NEW DEVELOPMENT BY BENDIX



FOR TURBINE ENGINES

Provides a continuous condensed display of turbine engine vibration and temperature conditions

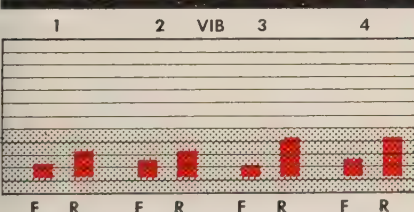
A landmark in engine instrumentation progress is the Bendix* Temperature-Vibration Monitor which simultaneously displays the findings of 40 temperature and 8 vibration sensors strategically located on all 4 engines of a turbine powered aircraft. This data is presented on the flight deck of the aircraft in bar graph form so that it can be continuously monitored and easily read.

The average displacement of 8 vibration pickups is displayed continuously on the lower cathode ray tube with the top of the bar graph indicating vibration displacement on the grid scale. This continuous monitoring of vibration immediately indicates excessive unbalance on the jet engine.

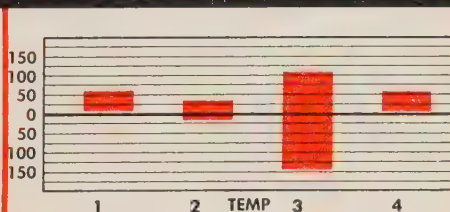
The temperature analysis normally associated with the exhaust gas thermocouples will locate faulty burners, bad combustion distribution and plugged nozzles or any unusual hot or cold

conditions around the turbine engine exhaust. The temperature display in the "all" position presents maximum and minimum temperatures on the upper cathode ray tube continuously for the four engines as reference to a temperature datum set in by the operator. The individual engine temperatures can be displayed as 10 bar graphs whose deflection can be read on the tube scale as deflections above or below the temperature datum, and individual degrees may be accurately and easily read from the digital read-out dial.

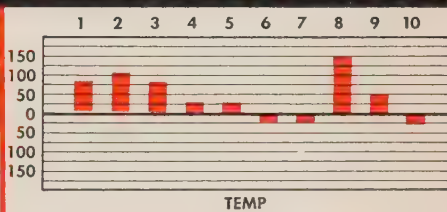
The equipment, initially developed for BOAC, is applicable to all airline and military turbine powered aircraft. The equipment for the four engine installation is approximately 30 lbs. and includes the Temperature-Vibration Monitor pictured above and a remotely mounted $\frac{1}{2}$ ATR short box. *TRADEMARK



Vibration indication for four engines with front and rear pickups on each. Height of display indicates total vibration displacement.



Temperature "all" display indicating maximum and minimum temperatures above and below temperature datum for four engines.



Temperature for single engine indicates all thermocouples indicating temperature above or below temperature datum reference.

Scintilla Division

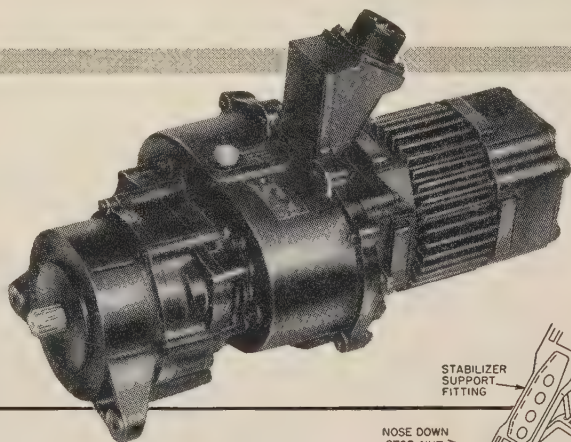
SIDNEY, NEW YORK



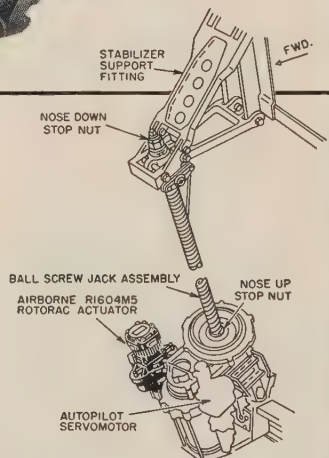
Write in No. 187 on Reader Service Card at start of Product Preview Section

AIRBORNE SPECIAL ACTUATOR

POWERS 707 TRIM SYSTEM



At right, a detail drawing of Boeing 707 horizontal stabilizer trim system. Airborne R-1604M5 ROTORAC actuator drives the screw jack, except when ship is on autopilot. Design duty cycle: 5 min. on, 5 min. off at 820 in.-lb. max. load, reversing every 4 sec. Weight of actuator—39.5 lb. Overall length—16 in.



Because of its function—operation of a primary flight control on Boeing's 707—this Airborne ROTORAC large special actuator must provide the utmost reliability under almost continuous off-on-reverse type operation. And its response must be quick, even though maximum torque and acceleration are limited by specification—to avoid inadvertent structural overloads.

To control torque, Airborne developed a special friction clutch which limits output to 1500 in.-lb. maximum and yet will transmit 1200 in.-lb. under any condition. Controlled accelerations were achieved by balancing the inertia characteristics of all rotating parts

and of the external load against the carefully tailored performances of the motor and servo clutches. Result: smooth acceleration from 0 to 180 rpm in 0.4 second and shock-free reversal in 0.1 second, both at full load.

Airborne offers you engineering of this caliber to meet needs for almost any special rotary or linear electromechanical actuator—large or small. And where requirements are not unique, we provide a line of modular-type actuators, developed by Airborne to simplify design and specification. Just give us the facts on your application and we will be happy to make a proposal. Contact any of our offices for further information.



Engineered Equipment for Aircraft and Industry

AIRBORNE ACCESSORIES CORPORATION

HILLSIDE 5, NEW JERSEY • Offices in Los Angeles and Dallas

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PRODUCT PREVIEW

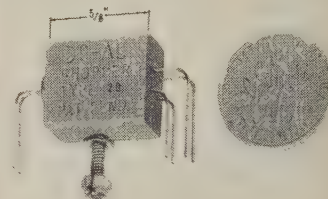
CREEP TESTERS achieve high heats

Two new Olsen-Smith stress-rupture-creep testing machines that assures uniform load application for indefinite periods will maintain testing temperatures to 2462 deg F, within plus or minus two deg, says Tinius Olsen Testing Machine Co., Dept. S/A, 804 Easton Rd., Willow Grove, Pa. Three individually regulated and controlled heating zones make possible accurate testing.

One of the compact, rugged machines has a 140 to 6000-lb capacity and the other, 280 to 12,000 lbs. A large dial indicator shows extension or creep measurements, and instrumentation is available for automatic plotting of the entire test.

Write in No. 270 on Reader Service Card

DC-AC CHOPPERS are micro-miniature



Housed in a $\frac{5}{16}$ x $\frac{1}{2}$ in x $\frac{5}{16}$ in metal casement, this chopper offers an extremely low noise level, a 2000 hr. life and operation from -65 deg C to +125 deg C, says Ravco Instruments, Inc., Dept. S/A, 3527 West Rosedale, Fort Worth, Texas.

The unit has a hermetically sealed contact closure, void of organic materials, and 150 electrical degree minimum dwell time. These SPDT choppers are available from stock for 6 V, 400 cps excitation and on special order from 0-1800 cps.

Write in No. 271 on Reader Service Card

COAXIAL CABLE is flexible type

This coaxial cable is designed to replace bulky semi-rigid types to be applied where miniaturized, flexible cable was needed capable of being bent over an 8 in diameter mandrel without major change in transmission characteristics. It has a maximum VSWR of 1.20:1 over a frequency range of 350-5000 megacycles, according to Times Wire & Cable Co., Inc., Dept. S/A, Wallingford, Conn. It has a capacity of 500 W of power at the highest frequency, and a limited attenuation factor.

Construction is of multiple semi-solid layers of Teflon mono-filaments, silicone-rubber-fiberglass-laminated tapes, it is said.

Write in No. 272 on Reader Service Card

VOLTAGE PACKS offer close regulation



Standard cells or dry cell batteries for equipment requiring stable voltage references may be replaced by these miniaturized voltage reference packs capable of maintaining voltages to within 0.01 per cent, says International Rectifier Corp., Dept. S/A, 1521 Grand Ave., El Segundo, Calif. The reference packs can be used in digital voltmeters, regulated power supplies, autopilots, and like applications.

Five pack types provide outputs of either 8.4 or 16.8 V dc, and they will allow operation from 28 V dc or 115 V ac, 400 and 60-cycle power supplies. Temperature coefficient of the devices is ± 0.001 per cent per deg from -55 to $+100$ deg C. The units are designed to withstand environmental and temperature extremes.

Write in No. 273 on Reader Service Card

BEARING needs no lubrication

These spherical bearings, rod end bearings, and bushings, which utilize a fluoron TFE fiber, have a very low coefficient of friction and need no lubrication, according to Radial Bearing Corp., Dept. S/A, Danbury, Conn. The bearings, which are low in cost, are useful in the aircraft and other fields.

Field tests in rugged aircraft applications have shown the bearings to give ten times the life of conventional bronze or steel-on-steel types. The bearings, which are self-aligning, offer a combination of properties excellently suited to low surface speeds, low unit loads, or applications subject to high dynamic loading. The design eliminates rotation of the inner race on the bolt throughout the load range, and there is thus no need for lubrication during the life of the bearings.

Write in No. 274 on Reader Service Card
more on next page

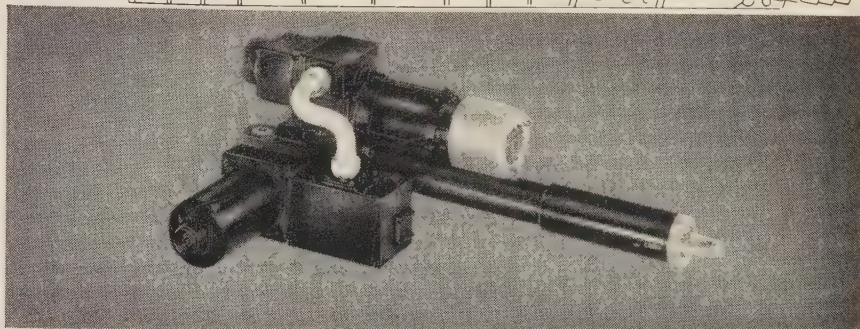
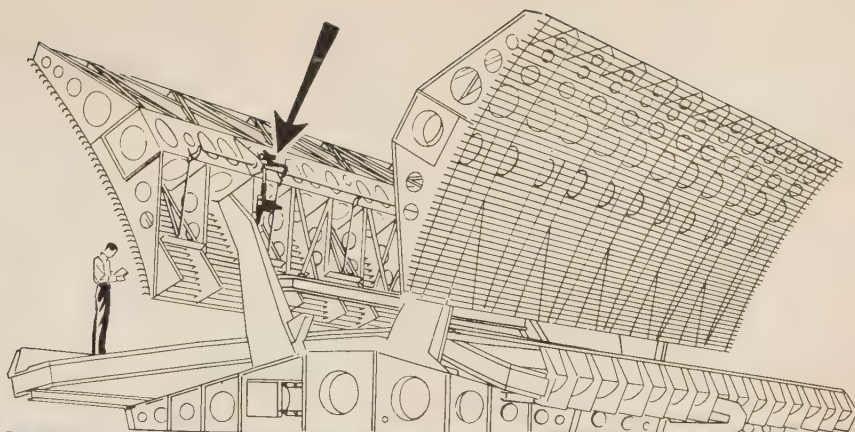


Photo courtesy Western Electric

R2552 LINEATOR exemplifies Airborne capabilities in large special actuators. Installed in pairs, units control tilt and shape of DEW Line antenna reflectors, must operate in temperatures from -65 to $+130^{\circ}\text{F}$.

Airborne large special actuators used for DEW Line antenna control

Airborne large special actuators are being employed today in a diversity of applications, both air and ground. On the DEW Line, for example, pairs of Airborne R2552 LINEATOR actuators are used to control the tilt and shape of AN/FPS-19 antenna reflectors. Environment in this instance involves extreme temperature and humidity conditions and these call for a high order of mechanical and electrical reliability.

The R2552 typifies Airborne's capabilities in developing large special actuators—linear or rotary. And where requirements are not unique, we also offer a line of

modular-type actuators, originated by Airborne to simplify design and specification. Write for further information.

GENERAL ENGINEERING DATA

Airborne Special Design
LINEATOR Actuator R2552

1. 208 v a-c, 60 cycle, 3 phase reversible induction motor with magnetic brake
2. Speed at rated load of 400 lb.: .3 in./sec.
3. Ambient temperature: -65 to $+130^{\circ}\text{F}$. (-80°F . non-operating). Relative humidity: up to 100%
4. Design incorporates 2 limit switches and 4 intermediate position switches, plus synchro position transmitter.



Engineered Equipment for Aircraft and Industry

AIRBORNE ACCESSORIES CORPORATION

HILLSIDE 5, NEW JERSEY

Represented in Canada by: WINNETT BOYD LIMITED • 745 Mt. Pleasant Rd., Toronto 14, Ont.

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CLAMPS by WITTEK

for the Space-Age

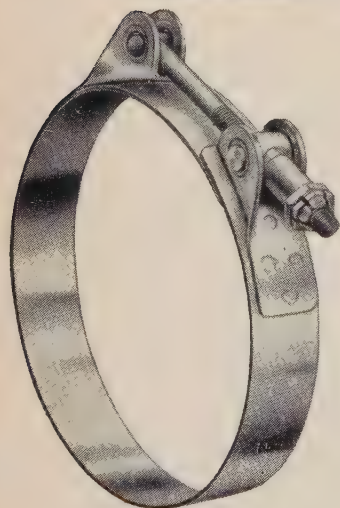
STAINLESS STEEL FLAT BAND CLAMPS

Complete range of sizes from 2 1/4" to 10" diameter



Quick-Latch Clamp—Series 10QL

Meets rigid military standards where easy installation and removal are important. The patented latch construction gives positive assurance against accidental disconnect. Basic materials and components meet MS requirements governing Part MS21920R.



T-Bolt Clamp—Series 10T

Same as 10QL but without patented quick-latch, and recommended for more permanent applications. Meets MS requirements governing Part MS21920.

STAINLESS STEEL AIRCRAFT CLAMPS

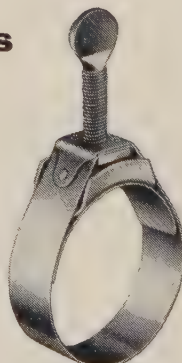
Complete range of sizes



Type AN737-TW
(with shoe)



Type AN737-TWLS
(without shoe)



Type AN737-RM
(floating bridge)

Descriptive literature or recommendations for any clamping requirements upon request.

Quality Clamps for over a Quarter Century

WITTEK MANUFACTURING CO.

4368 West 24th Place, Chicago 23, Illinois

Write in No. 190 on Reader Service Card at start of Product Preview Section



4825

PRODUCT PREVIEW

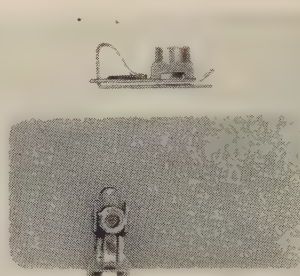
ROTARY SWITCH for printed circuits

This miniature precision rotary switch, with special 0.031 in diameter terminals that mount quickly in printed circuit boards up to 1/16 in thick, is designed for compact instruments, computers, and other electric-electronic equipment. It measures 1 3/4 in sq. and has a 1 in back-of-panel depth, says Shallcross Mfg. Co., Dept. S/A, Selma, N. C. It is available in shorting and non-shorting types with 1 to 4 poles per deck and up to 32 positions per deck.

It may be ganged up to 10 decks, only the last deck is furnished with printed circuit terminations. All other decks are standard miniature.

Write in No. 275 on Reader Service Card

FASTENER for one-side access



This SL 88 series clip-nut is a snap-on "U" type nut plate. It eliminates riveting and setting operations and requires only one hole, says Shur-Lok Corp., Dept., S/A, 879 So. East St., Anaheim, Calif. It is easily slipped over the panel edges; the extrusion on the clip snaps smoothly into the hole in the panel and the spring holds the clip firmly in place.

It is valuable wherever blind assembly is required on panel edges, such as airframe application in fastening floor panels to structure.

Write in No. 276 on Reader Service Card

SERVOMOTOR is radiation resistant

The Size 15 T175-001 servomotor is capable of high performance under high temperature and intense radiation conditions, says Kearfott Co., inc., Dept. S/A, 1500 Main Ave., Clifton, N.J. The unit operates over a -50 to +200 deg C range and will withstand 10⁸ through 10¹⁰ roentgens.

No load speed is 5000 rpm, minimum, and stall torque is 1.45 in.-oz. The stator is integrally cast in a thermosetting resin. This technique permits straight-through bores and minimum air gaps and results in greater efficiency.

Write in No. 277 on Reader Service Card
more on page 294



Piercing the **HEAT** **BARRIER!**

TITANIUM HUCKBOLT* FASTENERS offer up to 43% weight saving, high strength at elevated temperatures, fast installation with uniform tension and low installed cost.

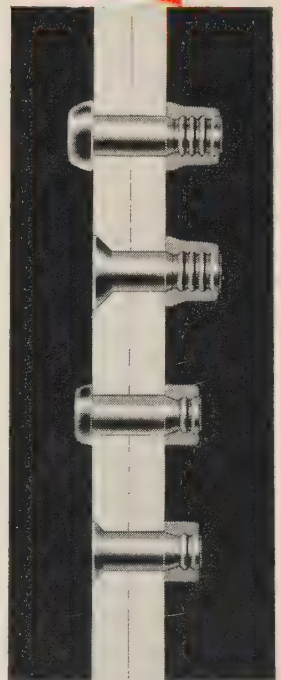
Titanium Huckbolt Fasteners can save as much as half a ton per average airframe with no compromise in strength or structural integrity.

Their excellent pull-together, high clinch and swaged lock assure maximum rigidity and elimination of vibration, stripping or shake out.

Installation is so simple that inexperienced operators can install fasteners accurately and uniformly at a rate that makes other fasteners expensive and obsolete by comparison.

Removal for service or repair is simple and without work damage.

*T.M. of Huck Manufacturing Company



For complete information—write or call licensees:

VOI-SHAN
MANUFACTURING COMPANY
division of VOI-SHAN INDUSTRIES INC.
3 Higuera Street • Culver City, Calif.
(Licensee)

HUCK
MANUFACTURING COMPANY
2480 Bellevue Ave., Detroit 7, Mich.

AIRCRAFT / MISSILE DIVISION
STANDARD PRESSED STEEL COMPANY

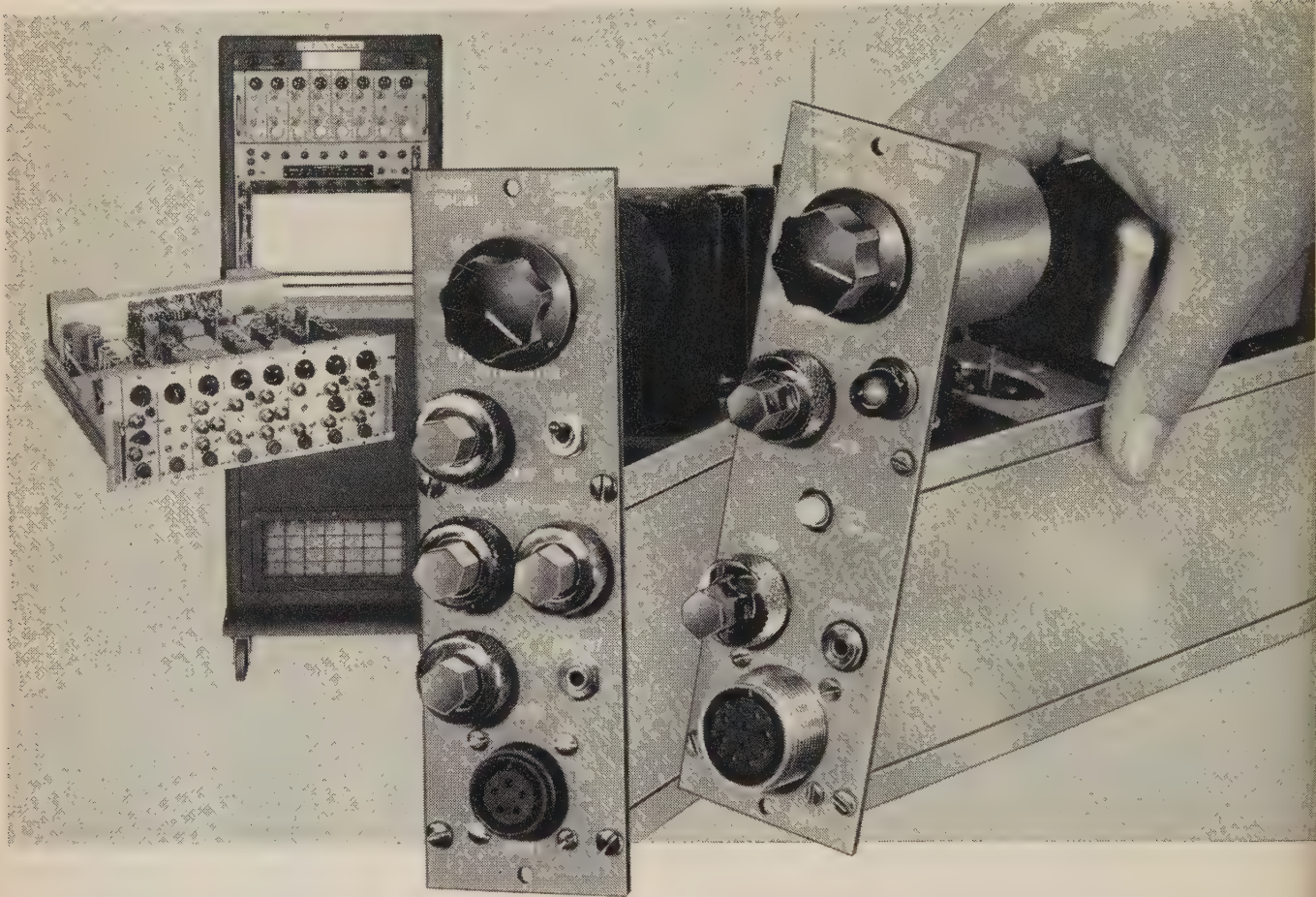
SPS
Jenkintown, Pennsylvania
(Licensee)

Licensed under Huck patents No. 2,527,307 2,531,048, 2,531,049 and 2,754,703
Write in No. 192 on Reader Service Card at start of Product Preview Section

NEW

**CARRIER AND LOW LEVEL PREAMPS
OFFER MORE RECORDING USEFULNESS**

**—per inch
—per dollar
—per channel**



WITH the availability of these two new plug-in preamplifiers and associated MOPA, Sanborn 6- and 8-channel "850" oscillographic recording systems can now record an even *wider* variety of inputs — wherever *many channels* are needed in *minimum panel space*, with *no* sacrifice in system accuracy or reliability. The 850-1100A is a carrier amplifier-demodulator unit designed to work with resistance bridge, variable reluctance and differential transformer transducers. Attenuator, smooth gain, position and balancing controls are on the 2" x 7" front panel; input and output connections are provided at both front and rear. The 850-1500A is a chopper amplifier with floating input isolated from a floating output, capable of measuring low level DC-100 cps signals such as those from thermocouples and strain gage bridges. Design provides low noise operation, greater freedom from ground loop interference and high common mode rejection ratio. Required carrier excitation (2400 cps standard, 600, 1200 and 4800 cps optional) and chopper drive (440 cps) voltages are supplied by the 850-1900 MOPA, a dual-oscillator unit which can handle up to eight of each preamplifier.

SPECIFICATIONS

	850-1100A	850-1500A
Sensitivity	100 μ v in gives 1 v at output	
Input impedance	approx. 2500 ohms	approx. 100,000 ohms
Output	± 2.5 v across 3300 ohms	± 2.5 volts across 2500 ohms
Freq. response	-3 db at 20% of carrier freq.	0-100 cps, -3db
Linearity	$\pm 0.5\%$ of full scale	$\pm 0.1\%$ of full scale
Common mode performance		120 db for 60 cps, 160 db for DC with 5000 ohms unbalance in input
Noise		2 μ v p-p over 100 cps bandwidth

(data subject to change without notice)



Ask your Sanborn Sales-Engineering representative for complete facts on all "850" system units — or write the main office in Waltham.

Write in No. 191 on Reader Service Card at start of Product Preview Section

SANBORN COMPANY

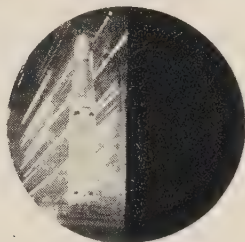
Industrial Division

175 Wyman St., Waltham 54, Mass.

SPACE/AERONAUTICS



and this is the way the range is run:



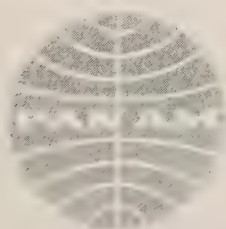
On the Atlantic Missile Range, time waits for no missile. Countdowns must be completed, missile test schedules must be met, orbital interceptions must occur.

Such critical time relationships are achieved only through exact planning, *missile range planning* – a vital part of our responsibility as prime contractor to the Air Force for operation and maintenance of the range.

Here is a pioneer art, encompassing every phase of missile ground support – from operations, engineering, test scheduling and quality control to facilities design, pad safety, propellant handling and nose cone recovery.

Here too, is a pioneer area for professional achievement for the qualified engineer, mathematician or physicist. If you are one such man, we suggest you investigate a future in missile range planning with Pan Am. Please address Mr. J. B. APPLEDORN, *Director of Technical Employment*, Pan American World Airways, Inc., Patrick Air Force Base, Florida, Dept. T-12.

PLANNING

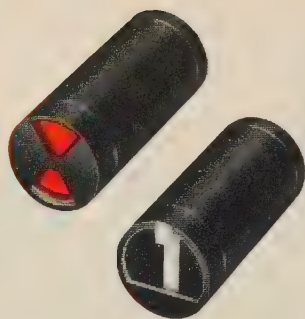


Guided Missiles Range Division
Patrick Air Force Base, Florida

Check Employment Inquiry Form on Page 193



actual size
Model HCM 7/16



MINIATURE 7/16" INDICATOR

Micro-miniature moving coil, core magnet indicator; 7/16" diameter, 31/32" length. Weight 10 grams; sealed. Available with a pointer or flag display in a wide variety of electrical sensitivities and functions. Data on request. Marion Instrument Division, Minneapolis-Honeywell Regulator Co., Manchester, New Hampshire, U.S.A. In Canada, Honeywell Controls Limited, Toronto 17, Ontario.

Copyright © 1959, Marion



Write in No. 194 on Reader Service Card

PRODUCT PREVIEW

ENCODER is highly accurate

A geared encoder assembly designed for use where minimum size and weight are important can resolve shaft positions to one part in 100,000, says Datex Corp., Dept. S/A, 1307 S. Myrtle Ave., Monrovia, Calif. The CG-703 assembly uses two shaft position encoders and a gear box, and the encoder on the input shaft provides 1000 positions of the least significant digit per 360 deg rotation.

Since the encoder couples directly to the input shaft, accuracy is that of the encoder used, plus or minus one count. The input unit is geared 100:1 to a 100 position encoder. The design provides for the elimination of ambiguities due to gear inaccuracy and backlash, and the inertia reflected back into the driving system has negligible effect on the drive requirements. Assemblies with higher number of positions are available, and over one million positions may be obtained through the addition of gearing and encoders.

Write in No. 278 on Reader Service Card

MOTOR-DRIVEN RESISTOR for remote control

A dc motor-driven, variable resistor designed for remote control applications, TV among them, has been offered in resistances ranging from 250 ohms to ten megohms by Chicago Telephone Supply Corp., Dept. S/A, Elkhart, Ind. Standard tolerances for the composition 1/4 to 1/2-W devices are ± 30 per cent for 250 ohms through five megohms and ± 40 per cent for five to ten megohms.

A six-V bi-directional dc motor-gear-train rotates the contact arm of the variable resistor at about five rpm, and the Type MD10 has a slip clutch to prevent damage if the unit is operated to the end of the control rotation. Voltage ratings across control end terminals and from bushing to terminals are 500 V dc and 1000 V ac, respectively.

Write in No. 279 on Reader Service Card

CIRCUIT BREAKER weighs 2 1/2 oz

This compact circuit breaker, 2300 series, weighs 2 1/2 oz. but it is said to have performance characteristics considered outstanding in those three times larger, according to Wood Electric Co., Dept. S/A, 244 Broad St., Lynn, Mass.

It has push-pull button action, protects circuits up to 5000 amps, 120v, 60 cycles. It is said to be highly shock resistant and precision calibrated.

Write in No. 280 on Reader Service Card

SAMPLING SWITCHES are long-lasting

Two long-life mechanical sampling switches, one for telemetry applications, have been developed by Cushman Precision Industries, Dept. S/A, 262 Alexander St., Princeton, N.J. The telemetry type includes a unit with three poles of 45 non-shorting channels per pole, an integral 400-cycle drive motor, and precision ball bearing gear reduction.

Sampling rate is 20 rps, and the device may be used for impedances from below 100 ohms up to over one megohm and voltages from 100 uv to over 100 V. Other models of the switch offer 30, 60, 90 channels at sampling rates up to 60 rps. All units operate in ambient temperatures from -60 deg C to $+135$ deg C, and 20 g vibration to 2000 cycles. The other switch, useful in commercial and military ground applications, is reported to require no service for a minimum of about one year continuous operation. It is available in 60-cycle, 400-cycle or dc drive motors, and with up to four poles of 100 non-shorting channels per pole.

Write in No. 281 on Reader Service Card

more on page 296

**What is
your
MISSILE
FASTENING
PROBLEM?**

Delron's NEW
ENGINEERING DATA MAY HAVE THE ANSWERS!

Our 48-page Catalog of Specialized Fastening Devices for High Temperatures and Sandwich Panel Fastening can help you select the right Fastener for your Missile Applications.

★ Write for your copy today!

...Fastener Specialists!

THE DELRON COMPANY, INC.
5224 Southern Avenue, South Gate, California
LOrain 7-2477

Write in No. 195 on Reader Service Card

LORAL

AIDS THE MISSION with its **A.I.D.S.*** SYSTEM!



Airborne Integrated Display System

The LORAL **ASW** Integrated Display System was developed in cooperation with various Naval activities and team contractors into a comprehensive display and tactical coordinated system which integrates the essential data from the various sensors and detecting devices carried in the aircraft.

The LORAL Ground Track Plotter, OA-1768/ASA-13, is located at the pilot's position to provide him with an unobstructed automatic plot of the aircraft's track and tactical situation. The Data Display Group AN/ASA-25 provides central programming and assignment controls for inputs to the electronic plotter. Thus, compared with other display systems and earlier techniques, **A.I.D.S.** assesses and enables rapid evaluation of related pieces of information into one comprehensive, well-coordinated display, which is essential in performing a successful **ASW** mission!

The **A.I.D. SYSTEM** is but one of many advanced concept systems in the fields of **ASW, Reconnaissance, Navigation, Guidance, Countermeasure** and other fields, developed or in course of development by LORAL.

LORAL, with its staff of experts in **plotting, guidance, reconnaissance, countermeasures** and many other phases of electronic warfare are at your disposal.

Wire or write us, about your system requirements.

SEARCH
AND
DETECTION

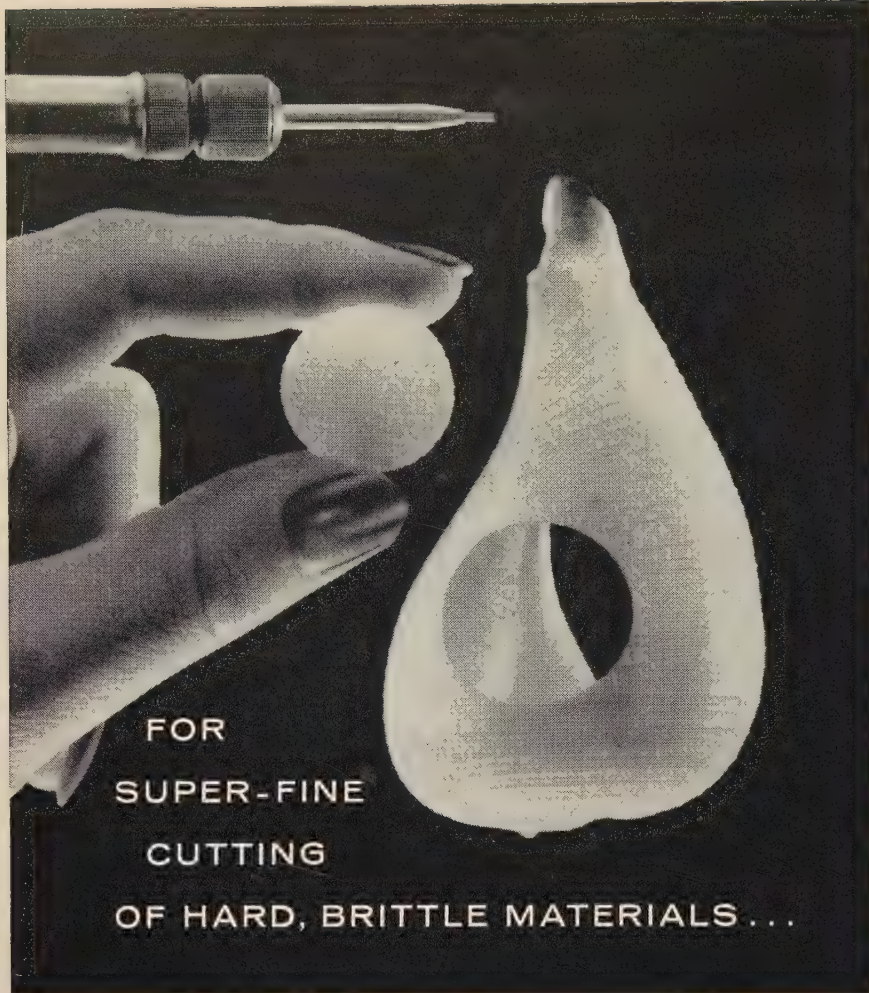
NAVIGATION
AND
LOCALIZATION

ATTACK!

LORAL

ELECTRONICS CORPORATION
DEPT. SA-1 NEW YORK 72, NEW YORK

Working in **AVIONICS • NAVIGATIONAL EQUIPMENT • VISUAL COMPUTER DISPLAYS • PLOTTERS • INDICATORS • ECM SYSTEMS • ASW SYSTEMS • RECONNAISSANCE SYSTEMS**
Write in No. 180 on Reader Service Card at start of Product Preview Section



THE *S.S. White* Industrial Airbrasive® Unit

We cut a section from this fragile sea shell just to show that *in a matter of seconds* almost any hard, brittle material can be cut or abraded with the S.S. White Industrial Airbrasive Unit.

Cool, shockless, super-precise, the unit uses a controlled stream of fine abrasive, gas-propelled through a small nozzle. It is so flexible in operation that the same simple tool can frost a large area or can make a cut as fine as .008" . . . on a production basis!

Almost every day new uses are being discovered for the Airbrasive Unit, in the lab or on the production line . . . shaping . . . deburring . . . wire-stripping . . . drilling . . . engraving . . . frosting . . . materials testing . . . cleaning off surface coatings.

All types of hard brittle materials . . . glass, germanium and other fragile crystals, ceramics, minerals, oxides, metal, certain plastics.

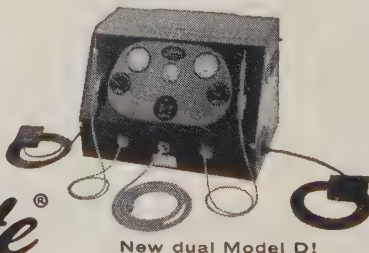
Send us your most difficult samples and we will test them for you.

1089



**SEND FOR
BULLETIN 5705A**
...complete information

S.S. White



New dual Model D!

S. S. WHITE INDUSTRIAL DIVISION • Dept. 21A • 10 East 40th Street, New York 16, N. Y.

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PRODUCT PREVIEW

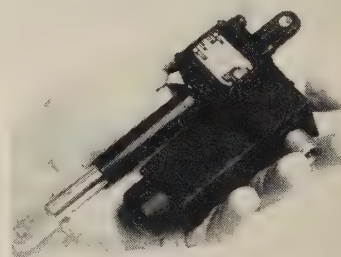
LOW LEVEL DC AMPLIFIER for telemetry use

Model DA-10 is a high temperature (100 deg C) completely solid state, DC instrumentation amplifier and handles typical low level strain gage and thermocouple inputs, says United Electrodynamics Inc., Dept. S/A, 120 So. Marengo Ave., Pasadena, Calif.

The amplifier features a balanced input, integral supply voltage regulator, transistorized chopper, and environmental characteristics suited to extreme flight conditions.

Write in No. 282 on Reader Service Card

LINEAR ACTUATOR has slip clutch



A one-lb, miniature linear actuator that handles loads up to 400 lbs uses an adjustable slip clutch in place of limit switches. The design also features a one-piece extruded flat-side housing readily adaptable to gear ratio changes and addition of other components, says Lear, Inc., Dept. S/A, P. O. Box 688, Grand Rapids 2, Mich.

The adjustable slip clutch absorbs the inertia of the motor rotor when the unit contacts the torsional stops at extend and retract positions, and it also provides overload protection. A choice of motor positions is available, and indicators, synchros of flex shaft take-offs may be added.

Write in No. 283 on Reader Service Card

TELEMETERING COMMUTATOR has long life

This Millivolt Telemetering Commutator has 300 times the life and reliability of circular sampling switches and will operate from 36 to 2500 cps 25C's applied vibration, withstanding 150C's shock for 11 millisecc, says Lind Corp., Dept. S/A, Research Park, Princeton, N.J.

The 2-pole, 60-contacts per pole switch samples 3 mv signals with ½ per cent accuracy and has less than 5 ohms contact resistance. The unit operates on ¾ W power, occupies only 11¼ cu in. and weighs 12 oz.

Write in No. 284 on Reader Service Card
more on page 298



4,000,000 miles of jet experience!

Count those zeros again! That's a lot of jet experience in anybody's record book. In terms of time, it means Air France started flying pure-jet aircraft as early as 1953. And the Air France Caravelle is still the talk of the aviation world and experienced jet travelers, setting record flight times from Paris to London, Rome, Nice, Tel Aviv, Istanbul and Africa.

Now Air France is concentrating these years of jet experience on the new Boeing 707 Intercontinental. This mighty jet is the largest, fastest, longest-range

airliner in the world. In fact, the Intercontinental is the first jet airliner designed to cross the Atlantic non-stop in 6½ hrs. between New York and Paris. In swift, silent, vibrationless flight, nothing equals this newest addition to Air France's jet fleet.

Air France is proud of these millions of miles of jet experience. They are more than just a record. They inspire in passengers and crews alike the confidence that comes with the knowledge that Air France has been a pioneer in jet aviation.

AIR FRANCE JET

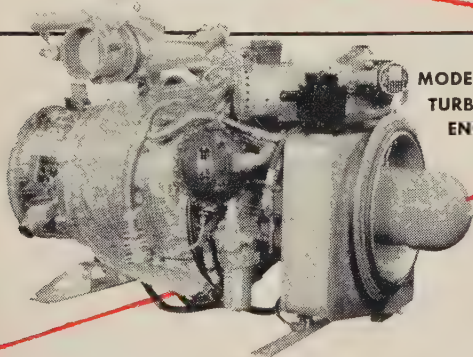
WORLD'S FASTEST JETLINER / WORLD'S LARGEST AIRLINE

Write in No. 157 on Reader Service Card at start of Product Preview Section

**SINCE 1954---
PROVED IN USE**

**---CAE TC-106
(USAF TYPE MA-1A)**

**PORTABLE
STARTING UNIT
FOR
LARGE JET AIRCRAFT**



**MODEL 141
TURBO-COMPRESSOR
ENGINE**

• This fine product of Continental development and manufacture, with the CAE Model 141 turbo-compressor as its heart, has a five-year record of exceptional performance to its credit.

... More than 1,000 MA-1A's and their predecessor MA-1's have been delivered to the Air Force since 1954. There, actual experience has led to upward revision of hours-between-overhaul schedules, with an eventual period well in excess of 2,200 starts indicated as likely. USAF-type units in use by certain aircraft manufacturers, and not subject to Air Force requirements as to return to overhaul, have exceeded 3,400 starts and are still in excellent operable condition, no change of major parts having been made ... Official Air Force records show low overhaul cost, in combination with 99.5 per cent service availability, and almost complete freedom from field down time for maintenance or modification—all in addition to the important factor of low initial price ... When it comes to USE-PROVED ground support equipment, CAE is first choice.



CAE gas turbine models—the famous J69's—are in Cessna's T-37A twin jet trainer, Ryan's Q2 Firebee target missile, Temco's TT-1 Navy jet trainer, and other aircraft. From the J69 have evolved the highly versatile new Series 356 turbines, including jet power for manned and unmanned aircraft up to 2,400 lbs. thrust, a boundary layer control air pump, and an aft-fan version turbojet, as well as a free shaft turbine of 3,500 hp.



CONTINENTAL AVIATION & ENGINEERING CORPORATION

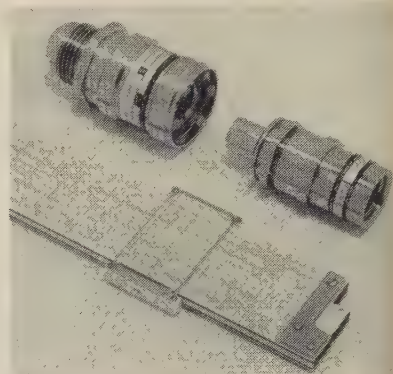
GENERAL OFFICES AND RESEARCH AND DEVELOPMENT DEPARTMENTS AT 12700 KERCHEVAL AVENUE, DETROIT 15, MICHIGAN ... PRODUCTION DIVISION AND FIELD SUPPORT, 1330 LASKEY ROAD, TOLEDO, OHIO.

SUBSIDIARY OF CONTINENTAL MOTORS CORPORATION

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PRODUCT PREVIEW

**CONNECTOR
has new sealing**

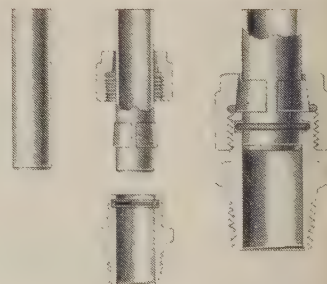


This Inst-O-Matic connector compatible with existing exotic and cryogenic fluids in the missile and rocket field has an expanded temperature range of -320 to ± 650 deg F due to the development of a new sealing design, says E. B. Wiggins Oil Tool Co., Inc., Dept. S/A, 3424 E. Olympic Blvd., Los Angeles 23, Calif.

It is available in sizes $\frac{1}{4}$ in. through two inches in aluminum and stainless steel. It is designed for operating pressure up to 4500 psi and burst pressures of 12000 psi. It is said to be quick connector, light, and simple to operate. Some applications suggested are: liquid rocket propellants, topping lines, sensor lines, test stands and breathing oxygen converters and systems.

Write in No. 374 on Reader Service Card

**TUBE FITTING
is O-ring-sealed**



This O-ring fitting is used on vacuum, air, and hydraulic systems and seals by means of an O-ring. A split tapered sleeve holds the tubing in place when the clamping nut is drawn up. Excessive wrench torque is unnecessary because the seal does not depend on the tightness of the nut, says Lenz Co., Dept. S/A, Box 1044, Dayton 1, Ohio. No exact tube length is necessary.

No metal to metal seal, so no concentration of stresses due to flares or ferrules for tube failures, which, it is said, makes it a superior fitting under shock and vibration.

Write in No. 375 on Reader Service Card
more on page 300



**in this zone,
stainless steels that
remain ductile with
high strength and stability**

In the search for favorable strength-to-weight ratio, high temperature alloys have been developed with extreme strength up to 1000 F, but at the expense of ductility.

In AM 350 and AM 355, Allegheny Ludlum's precipitation hardening stainless steels, you have high hardness and stability from room temperature to 1000 F, plus almost twice the ductility!

These advantages are followed by easy formability using normal techniques. AM 350 and AM 355 can be brazed and welded as easily as the common stainless steels. They can be spun, formed and machined without special preparation.

AM 350 is available commercially in sheet, strip, foil, small bars and wire. AM 355, best suited for heavier sections, is available commercially in forgings, forging billets, plates, bars, wire, sheet and strip.

For further information, see your A-L sales engineer or write for the new technical booklet, "AM 350 and AM 355." Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Penna.

861

ALLEGHENY LUDLUM




EVERY FORM OF STAINLESS . . . EVERY HELP IN USING IT

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IPECO

YOUR SOURCE FOR



Complete Facilities for all
molded and machined parts and...

**A Complete Stock of
SHEETS—RODS—TUBES**

Expanded Facilities and Increased
Engineering Personnel are all
part of IPECO's New Look...de-
signed to serve more industrial
users, *better*

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**INDUSTRIAL
PLASTIC**

AND EQUIPMENT COMPANY, INC.

116C MAIN ST., ORANGE, N. J. • OR 5-4740

*Registered Trade Mark—Dupont

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**SPACE
FLIGHT**

Volume I:

**ENVIRONMENTAL AND
CELESTIAL MECHANICS**

By **Kraft A. Ehricke**
Program Director, Centaur
and Vega Program,
Convair-Astronautics



Latest in
"Principles of Guided Missile Design" Series
Grayson Merrill, General Editor

Covers the concepts of space flight, its
environment, astronomy from the view-
point of the astronautical engineer, and
principles and methods of celestial me-
chanics. Comprehensive data tables,
graphs, many derivations and equations
of notion are helpfully included.

650 pages, about \$15.00

—Coming Soon—

Volume II: Dynamics

Volume III: Operations

VAN NOSTRAND

Princeton, N. J.

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PRODUCT PREVIEW

**FLAW DETECTOR
is portable**



The low cost, light weight and sim-
plified operation of the Sonoray Mod-
el 5 ultrasonic flaw detector have re-
sulted from a new design approach
to the application of the pulse echo
detection principle, says Branson In-
struments, Inc., Dept. S/A, 40 Brown
House Rd., Stamford, Conn. The por-
table unit, equally useful as a field
or laboratory instrument, is reported
to have half the weight, one-third the
volume, and twice the range of use-
fulness of comparable instruments.

The instrument, which can be used
for both contact or immersion work,
provides a continuous range of test
frequencies by virtue of its broadband
amplifier. The Sonoray automatically
adjusts to any transducer within the
0.4 to ten-mc operating range. The
transducers are equipped with quick
disconnects, and changing frequency
takes only five sec. Also featured is
a pyramid marker, which is especially
useful for determining flaw location
when ultrasonic pulses are beamed
into the material at any angle.

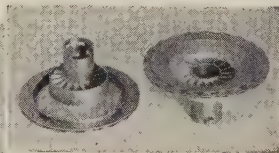
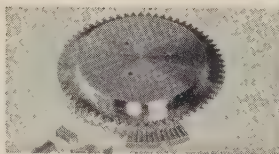
Write in No. 285 on Reader Service Card

**ULTRASONIC CLEANER
uses many frequencies**

The VT-700 ultrasonic cleaner
brings about a degree of cleanliness
not attainable before, a feat achieved
by the simultaneous use of a number
of frequencies, says McKenna Labo-
ratories, 2503 Main St., Santa Monica,
Calif. The unit runs at 400 kc to
remove one-micron dirt particles and
uses a number of lower frequencies,
ranging down to 20 kc, to remove
large particles and clean areas not
accessible to high frequencies.

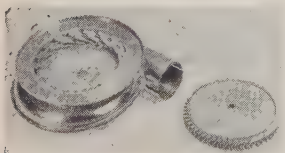
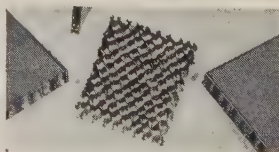
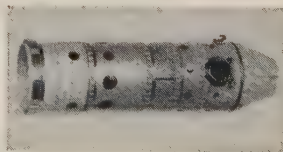
Applications include the cleaning
of valves, porous metal filters, gears,
potentiometer parts, and complex
mechanical assemblies. A complete
cleaning system provides wash, rinse,
and drip dry functions. The cleaning
containers have a 24-qt capacity.

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We Furnace Braze Stainless Alloys
*To eliminate problems of distortion,
stress, oxidation, and porous welds*

The advantages of stainless alloy brazing in dry
hydrogen or vacuum environment furnaces are
many. And the use of brazing for high-tempera-
ture service parts is growing just as fast as
potential users learn to design for it. We offer
technical design assistance to further the ac-
ceptance of this modern joining technique. Ten
years of pioneering this field, plus operating
three stainless processing plants, plus manu-
facturing our own Nicrobraz® brazing alloys,
fully qualifies us to give initial guidance to your
design crew in planning brazed stainless com-
ponents. Call TWInbrook 3-3800 in Detroit, or
write to find out how we might help you.

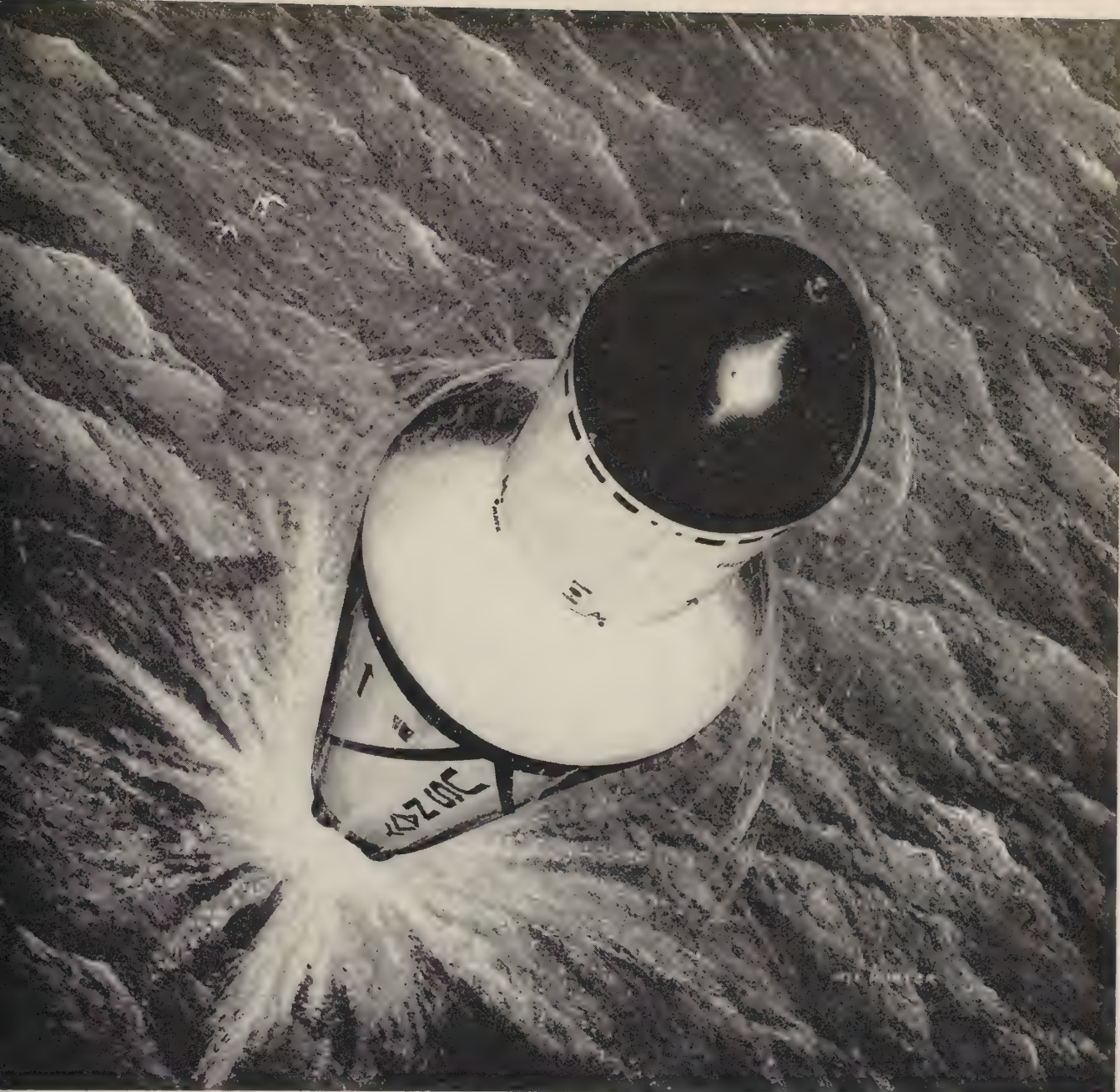


**STAINLESS PROCESSING DIVISION
WALL COLMONOY CORPORATION**

19345 John R Street • Detroit 3, Michigan

There are Wall Colmonoy furnace plants in Detroit, Michigan;
Morrisville, Pennsylvania; and Montebello, California

Write in No. 200 on Reader Service Card at start of Product Preview Section



Project: **SALT WATER PUNCH**

Filter Application: **PROTECT HYDRAULIC CONTROLS**

Filter: **PUROLATOR**
.....

the Polaris and the nuclear powered submarines which will carry and launch it form a mobile striking force that commands respect. Wherever they may be, it is imperative that, when the signal is given, the Polaris takes off and goes straight to the target.

Hydraulic control circuits play an important role in the programmed flight of the Polaris. To insure against malfunctions in the circuits, Purolator filters are designed as

an integral part of many of them, to specifications set by Lockheed Missiles and Space Division, Polaris missile system manager.

Purolator engineers will gladly bring to your needs the filtration knowledge they provide for Polaris and other top-priority projects. A letter or phone call describing your aircraft or missile filtration requirements will receive prompt attention.

*Filtration
For Every Known
Fluid*

PUROLATOR

PRODUCTS, INC.

RAHWAY, NEW JERSEY AND TORONTO, ONTARIO, CANADA

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data preview

FASTENER INSERTS—The new line of Min.O.Deer (minimum outside diameter) fastener inserts, designed to repair damaged threads, protect internal threads, and strengthen assemblies and light castings, has been described in an eight-page catalog prepared by Lock Thread Corp., Dept. S/A, 2832 E. Grand Blvd., Detroit 11, Mich. The device achieves excellent holding power by gripping the entire insert length.

Write in No. 287 on Reader Service Card

TRANSFORMER—A data sheet describing a small, 50 watt transformer, provides complete technical specifications and includes dimensional drawings. It has been issued by Arnold Magnetics Corp., Dept. S/A, 4613 W. Jefferson Blvd., Los Angeles 16, Calif.

Write in No. 288 on Reader Service Card

TESTING—Test facilities design and construction is the subject of a bulletin by Propulsion Test Facilities, Inc., Dept. S/A, 20 Fitch St., New Haven 11, Conn. Bulletin 100 discusses environmental test facilities, including vibration, altitude, temperature, pressure and their combinations.

Write in No. 289 on Reader Service Card

VIBRATION EXCITER—A vibration exciter for environmental testing, designated Model C125, is described in a bulletin prepared by MB Mfg. Co., Dept. S/A, Box 1825, New Haven, Conn. It includes design, operation, and features. The bulletin is Rel. 113.

Write in No. 290 on Reader Service Card

WELDING CONNECTIONS—A complete line of arc welding cable connections and accessories is described in Catalog 12 issued by Tweco Products, Inc., Dept. S/A, P.O. Box 666, Wichita, Kan. Ground clamps, electrode holders, mechanical lugs, cable connection supports, and ball point cable splicers are among the devices covered.

Write in No. 291 on Reader Service Card

SCREW ASSEMBLIES—A four-page brochure containing data on precision actuator screw and nut assemblies for missiles, aircraft, radar, instruments and other applications is available from Jerback-Bayless Co., Dept. S/A, Solon Rd., Solon, O. Size capabilities thread specifications, and materials are among the areas covered.

Write in No. 292 on Reader Service Card

TAPE SYSTEM—A multichannel magnetic tape system for laboratories, test cells, telemetering recording and other precision applications has been described in Catalog DC-3171 by Minneapolis-Honeywell Regulator Co., Dept. S/A, 10721 Hanna St., Beltsville, Md. The 24-page publication offers extensive performance specifications for transports and FM PDM, direct and digital tracks.

Write in No. 293 on Reader Service Card

FACILITIES—A 12-page booklet describing its facilities and capabilities has been prepared by Bohanan Mfg. Co., Dept. S/A, 15800 S. Avalon Blvd., Compton, Calif. It manufactures cartridge-actuated separation mechanisms, electro-servo actuators, fuel umbilical disconnect systems, hydraulic quick disconnect couplings and other hydraulic, pneumatic and electro-mechanical components. Product and plant illustrations and photographs are included.

Write in No. 294 on Reader Service Card

LITHIUM—Bulletin 101 describes the characteristics of lithium metal, including technical information illustrated with graphs, statistical tables, and line drawings, has been prepared by Foote Mineral Co., Dept. S/A, 18 W. Chelton Ave., Philadelphia 44, Pa. It also provides data on applications in chemistry and metallurgy.

Write in No. 295 on Reader Service Card

GEAR TRAINS—Catalog #575 includes 24 pages of complete description of all parts necessary for the assembly of complicated gear trains and servo-mechanisms. It has been prepared by Beckman Instruments, Helipot Div., Dept. S/A, 2500 Fullerton Road, Fullerton, Calif. It contains typical schematics and basic synchro transmitter and receiver systems, potentiometer transmitter and receiver systems, and a mechanical resolver system.

Write in No. 296 on Reader Service Card

TIMING DEVICES—A four-page brochure intended for design engineers, gives a capsule review with cut-away photos of mechanical timers, time switches and time delayed relays. The folder, BX265, issued by M. H. Rhodes, Inc., Dept. S/A, 30 Bartholomew Ave., Hartford 6, Conn., lists uses and typical assignments solved by the use of timing devices.

Write in No. 297 on Reader Service Card

SYNCHROS—Brochures describing military synchros and military and commercial autosyn synchro indicator, autosyn synchro transmitters, and aircraft pressure switches are discussed in data sheets No592-4 and No592-16 prepared by Bendix Aviation Corp., Montrose Div., Dept. S/A, S. Montrose, Pa. They include charts, engineering data and illustrations.

Write in No. 298 on Reader Service Card

O-RINGS—A comprehensive booklet outlining the physical and mechanical considerations of O-ring selection has been prepared by Auburn Mfg. Co., Dept. S/A, Middletown, Conn. It contains engineering data and reference tables simplifying selection, installation, lubrication, and maintenance of O-ring seals.

Write in No. 299 on Reader Service Card

DEMODULATION—LVDT Application Note 59-14, an eight-page discussion on demodulation techniques for linear variable differential transformers, has been prepared by Schaevitz Engineering, Dept. S/A, Pennsauken, N.J. The bulletin describes a modified circuit containing special transformers in which the reference voltage phase shifts simultaneously with signal voltage to keep a constant relative phase angle between the two voltages.

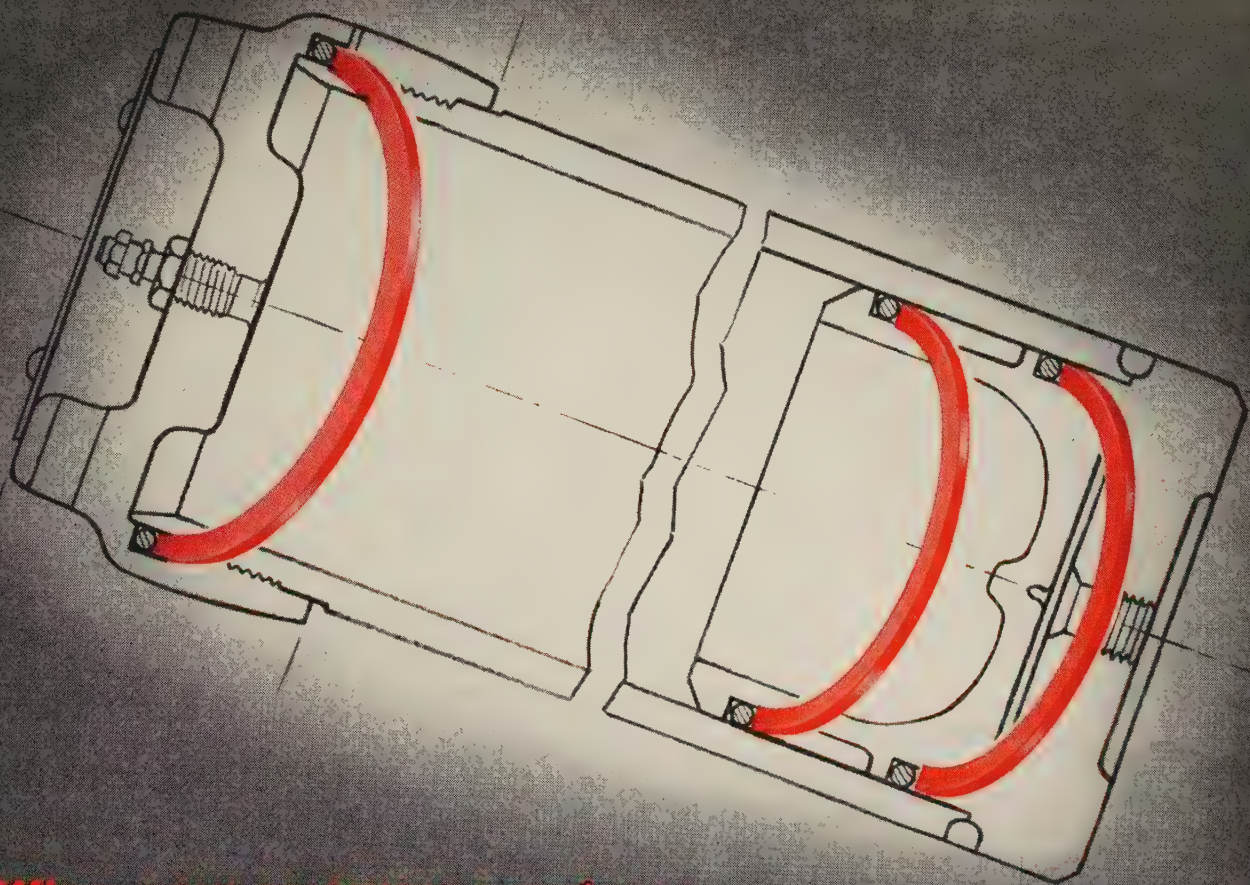
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FIBERGLASS STRUCTURES—Strong, lightweight filament-wound fiberglass structures used in aircraft, missiles, and space probes have been described in an illustrated, eight-page brochure, "Fiberglass Structures," issued by Aviation Div., Walter Kidde & Co., Inc., Dept. S/A, Belleville 9, N.J. The forms may be used as radomes, nose cones solid propellant rocket motor cases, and structural tubing.

Write in No. 301 on Reader Service Card

NOISE CONTROL—The problem of noise deriving from jet aircraft, high speed industrial machinery and centralized air conditioning systems, and control methods is the subject of a brochure by Industrial Acoustics Co., Dept. S/A, 341 Jackson Ave., New York 54, N.Y. It describes jet silencing systems, air conditioning vent silencing systems, soundproof rooms and enclosures used by industry and other applications.

Write in No. 302 on Reader Service Card
more on page 304



When LOW FRICTION counts . . .

Look for back-up rings of TFE resins

To reduce frictional drag to a minimum and to prolong the life of O-rings, three back-up rings of TEFLON TFE resins are used in the accumulator of a hydraulic cranking system (shown above). The accumulator operates at pressures up to 3,000 p.s.i. and the back-up rings of TEFLON TFE resins prevent the extrusion of the relatively soft O-rings. In operation, some of the TEFLON TFE resin is deposited on the O-rings as they move about the groove, further reducing friction drag.

The exceptionally low static coefficient of friction of TFE resins—only 0.04—is one of the reasons why back-up rings made of TFE resins help assure efficient, trouble-free performance in any application. They provide longer life, safer and more reliable operation and reduced maintenance problems in

everyday seal designs, as well as in applications that involve adverse conditions, like temperature extremes or corrosive problems.

When considering the time spent in the design, manufacture and installation of seals for use in aviation products and production, it is sound economic practice to put a quality material at the heart of the seal. Find out more about the unique advantages offered by TFE-fluorocarbon resins in back-up rings and in all types of seals. For product and design information consult your local supplier. Look for him under "Plastics—Du Pont" in the Yellow Pages, or write to: E. I. du Pont de Nemours & Co. (Inc.), Advertising Department, Room T-61, Nemours Bldg., Wilmington 98, Delaware.

In Canada: Du Pont of Canada Ltd., P. O. Box 660 Montreal, Que.



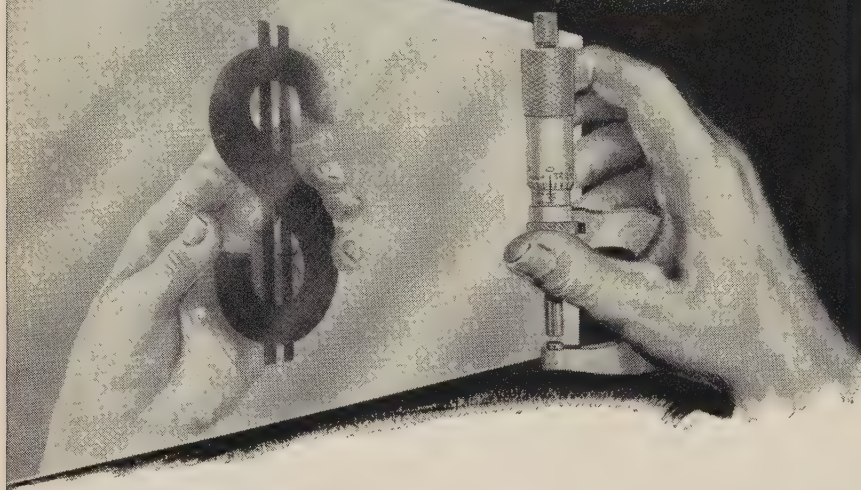
TEFLON[®]
TFE-FLUOROCARBON RESINS

TEFLON is Du Pont's registered trademark for its fluorocarbon resins, including the TFE (tetrafluoroethylene) resins discussed herein.

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

Write in No. 203 on Reader Service Card at start of Product Preview Section

How much does each .001" of Stainless Steel Sheet cost?



Example: In Type 302, an 18 gauge 36" x 120" sheet has a base price of 52¢ per pound. In sheets of this size, each .001" of thickness weighs 1.26 pounds per sheet. Thus, each .001" of unnecessary thickness costs you at least 65.5¢ more per sheet.

On the surface this may seem insignificant, but it has a marked effect on the total price you pay for a given quantity of stainless steel sheet. With cost a factor, this can be important since stainless steel is purchased by weight.

Using the above example, a mere .001" of unnecessary thickness costs you \$20.76 more per ton. If you figure the maximum allowable gauge thickness variation of plus or minus (10%), you can readily see that the price you pay for overall sheet thickness could involve much needless cost.

Washington Steel has the equipment and the experience to produce MICROROLD stainless steel to tolerances much closer than standard industry tolerances. Usually money can be saved by first selecting the minimum gauge that will serve the requirements of the application, and then specifying that the thickness be rolled to the light side of the gauge range. This specification involves no cost extra and is standard practice at Washington Steel. (If exact close tolerances must be guaranteed, there is a nominal additional charge.)

Consult your nearest MicroRold Stainless Steel Distributor. He will gladly show you how to save money on your stainless steel purchases.

Washington Steel Corporation

1-V Woodland Avenue
Washington, Pa.



Write in No. 204 on Reader Service Card at start of Product Preview Section

GLASS-CERAMIC — The third in a series of progress reports on the Pyroceram glass-ceramic materials has been issued as an eight-page Brochure PY-3 by Corning Glass Works, Dept. S/A, Corning, N.Y. Electrical, mechanical, thermal and chemical properties are included for the materials, which can be used for missile radomes, and other aircraft and missile applications.

Write in No. 303 on Reader Service Card

TOOLING PLATE—A brochure that includes property, specifications and availability information on Type 33 wrought aluminum tooling plate has been issued by Reynolds Metals Co., Dept. S/A, Box 2346, Richmond 18, Va. The plate is said to be useful where maximum stability, flatness, workability and ease of handling are necessary, and to meet the stringent quality requirements of the aircraft industry.

Write in No. 304 on Reader Service Card

CONTOUR MACHINING—Machining of stainless steel honeycomb for aircraft and missile construction is discussed in a bulletin by Ekstrom, Carlson & Co., Dept. S/A, 1400 Railroad Ave., Rockford, Ill. The publication describes an electrolytic method for which the company has applied for patents.

Write in No. 305 on Reader Service Card

RESISTORS—Complete data on the expanded line of Series 77 metal film precision resistors, which includes smaller units for miniaturization and larger sizes for greater range, are offered in Bulletin 155 by Ohmite Mfg. Co., Dept. S/A, 3629 Howard St., Skokie, Ill. Included is information on the equivalent styles under MIL-R-10509C and MIL-R-19074B.

Write in No. 306 on Reader Service Card

TUBING—A small tube price list explains innovations to simplify figuring and includes a table showing standard commercial tolerances. The guide has been prepared by Small Tube Products, Inc., Dept. S/A, Spring Meadows, Altoona, Pa.

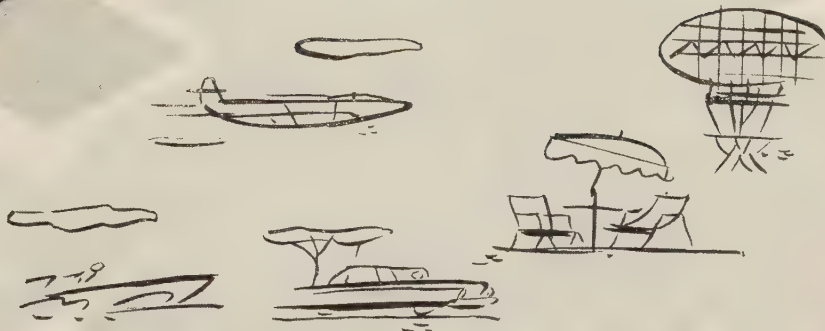
Write in No. 307 on Reader Service Card

SANDWICH CORE—Multiwave, a sandwich core material made out of continuous strips of aluminum foil crimped into a sine-wave pattern, has been described in Bulletin SP-1 by Narmco Resins & Coatings Co., Dept. S/A, 600 Victoria St., Costa Mesa, Calif. The material also has alternate foil ribbons of a second sine wave, a design that contributes to the materials excellent formability.

Write in No. 308 on Reader Service Card

more on page 306

LOOK
FOR THE
**DIAMONDS—SIGN
OF FINISHING
QUALITY**



Only

IRIDITE®

Process Engineered

Chromate Conversion Coatings

Give you 5 additional benefits for Corrosion Protection—Paint Base—Decorative Finishing

1

A COMPLETE PROCESS ENGINEERED LINE

Developed for specific applications, there is an Iridite to provide the finish you desire, fit the equipment you have available and give the performance you require. Most Iridite coatings meet rigid military and civilian specifications.

2

EXPERIENCED TECHNICAL SERVICE

Our large field engineering staff is thoroughly familiar with chromate conversion coatings and related finishing operations. They'll help you check every step in your finishing operation to make sure you're getting the best possible finish on your products.

3

PRODUCT AVAILABILITY

Warehouses located in strategic industrial

areas enable us to provide you with fast, economical delivery on any Iridite.

4

ECONOMY

The superior performance of Iridite provides low final cost by extending operating life and lowering maintenance costs. In addition, Iridite gives you a finish that adds considerably to the value of your product. There's an Iridite to meet every cost and performance requirement.

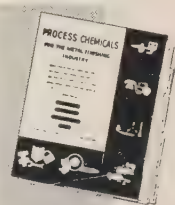
5

RESEARCH AND DEVELOPMENT FACILITIES

If you have an unusual application, we will gladly work with you. Our entire staff of experienced engineers and chemists, and our completely equipped facilities are at your service.

IRIDITE—a specialized line of chromate conversion coatings for non-ferrous metals. Apply by dip, brush or spray methods — at room temperature — manually or with automatic equipment. Forms a thin film which becomes an integral part of the metal. Cannot chip, flake or peel. No special equipment, exhaust systems or specially trained personnel required.

If you are using chromate conversion coatings to finish zinc, cadmium, aluminum, magnesium, silver, copper, brass or bronze — consider the above benefits of Iridite. For complete information, contact your Allied Field Engineer. He's listed under "Plating Supplies" in the yellow pages. Or, write for **FREE TECHNICAL DATA FILE**.



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Chemical and Electro-
chemical Processes, Anodes,
Rectifiers Equipment, and Supplies for Metal Finishing

IRIDITE®
Chromate
Coatings

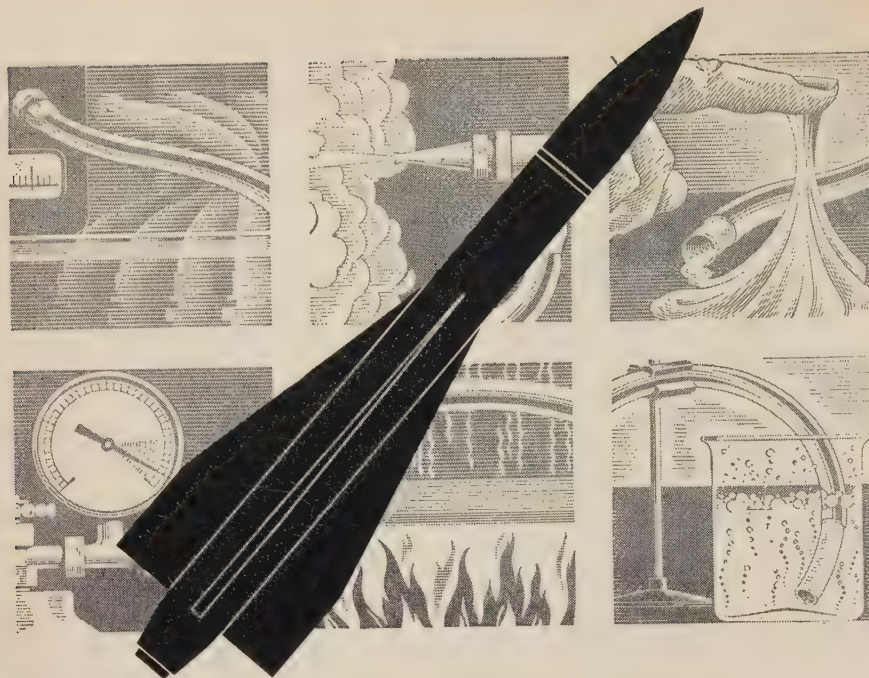
IRILAC™
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Coatings

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Brighteners

ARP®
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Equipment

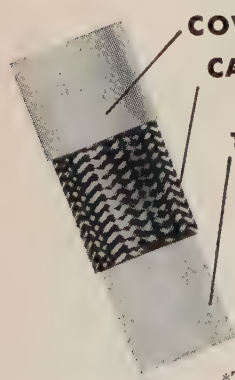
Write in No. 205 on Reader Service Card at start of Product Preview Section



NEW MALTESE CROSS TEFLON HOSE WITHSTANDS OXIDIZERS AND ROCKET FUELS

Almost every aviation use is covered with this amazing new Hewitt-Robins TEFLON*-lined hose. It is ideally suited for fueling all kinds of rockets, missiles, and advanced aircraft . . . and because of its anti-hesiveness, it is easily and thoroughly cleaned for other uses. Its flexibility permits use on reels for compact ground support applications.

Here's a look at some other reasons its service life is many times that of conventional hose:



COVER of tough, abrasion resistant neoprene.

CARCASS of steel wire braid for strength and flexibility.

TUBE with high quality TEFLON lining.

*Write today to Hewitt-Robins, Stamford, Connecticut,
and ask for Bulletin 9-25-S-603.*

**AVAILABLE IN SOME SIZES
IN LENGTHS UP TO 50 FEET**

*TEFLON is a trademark of E. I. DuPont de Nemours & Co.



HEWITT-ROBINS

CONVEYOR BELTING AND IDLERS . . . POWER TRANSMISSION DRIVES
INDUSTRIAL HOSE . . . VIBRATING CONVEYORS, SCREENS & SHAKEOUTS

H-R Product Manufacturing Plants in Buffalo, N. Y. • Chicago, Ill. • King of Prussia, Pa. • Passaic, N. J.
Amsterdam, Holland • Johannesburg, South Africa • London, England • Montreal, Canada • Paris, France

Write in No. 206 on Reader Service Card at start of Product Preview Section

DATA PREVIEW

RHEOSTATS—Precise current control features of the Jagabi Lubri-tact rheostat are shown in bulletin 41 issued by James G. Biddle Co., Dept. S/A, 1316 Arch St., Philadelphia, Pa. Technical and engineering data, drawings and illustrations are included.

Write in No. 309 on Reader Service Card

HONEYCOMB—Detailed information on various types of sandwich applications for honeycomb has been presented in the 45-page Handbook, "Honeycomb Sandwich Design," prepared by Hexcel Products, Inc., Dept. S/A, 2332 Fourth St., Berkeley 10, Calif. Handbook coverage includes primary functions of the component parts of a sandwich, stress data, design formulae for various loading conditions, and sandwich material selection.

Write in No. 310 on Reader Service Card

MAGNETIC CIRCUIT—The Halltron magnetic circuit MC-1, a device designed to satisfy the requirements for applications such as choppers, analog multipliers, power meters, and other electronic functions is the subject of the four-page Bulletin HT-MC-1, issued by Ohio Semiconductors, Inc., Dept. S/A, 1035 W. Third Ave., Columbus 8, O. The design calls for operation from dc through the audio frequency range.

Write in No. 311 on Reader Service Card

ELECTRIC MOTORS—A 12-page catalog describing and illustrating fractional horsepower electric motors, blowers, and special products has been prepared by Redmond Co., Inc., Dept. S/A, Owosso, Mich. It includes shaded pole, permanent split capacitor, and DC motors. Dimension diagrams, standard ratings, and other engineering information are included.

Write in No. 312 on Reader Service Card

ELECTRONIC COMPONENTS—Resistors, switches, relays and rheostats are among the components described in a comprehensive publication by Ohmite Mfg. Co., S/A, 3630 Howard St., Skokie, Ill. Catalog 30 also covers potentiometers, tantalum capacitors, and a line of variable transformers.

Write in No. 313 on Reader Service Card

RECTIFIER—A step-by-step method for selecting specific selenium rectifiers for circuit applications has been presented in the 24-page Brochure ECG-344 by Semiconductor Products Dept., General Electric Co., Dept. S/A, Syracuse, N.Y. The three-section publication also covers basic information and product descriptions.

Write in No. 314 on Reader Service Card

more on page 208

Applied Lessons from our ASW History



To date ERCO is the largest supplier of ASW tactics trainers to the U.S. Navy*

The prime requisite in the design and ultimate construction of these units is Systems Comprehension. To its Systems Comprehension ERCO adds Human Engineering so the many subsystems that make up an ASW airborne system can be successfully integrated . . . not only for training purposes but for the mission itself.

As a result of designing the complete tactics trainer, with the overall system requirement as the criteria, ERCO has acquired the position of being an objective observer. By combining the knowledge gained through building ASW tactics trainers . . . along with our Special Purpose Computing Techniques . . . we have under development the AID (Automatic Integrated Display).

AID will make computer decisions in conjunction with an integrated display . . . thereby reducing or eliminating the operator's arithmetic functions, leaving the human mind completely free for situation analysis and tactical decision.

AID is just one of the many development programs at ERCO which have resulted from a comprehensive ASW history. Perhaps the lessons we have learned and applied so well can assist you in your current projects.

To arrange for professional discussion at your facility please contact:

ERCO

DIVISION QCF INDUSTRIES INC., RIVERDALE, MARYLAND

OTHER QCF DIVISIONS: ALBUQUERQUE • AMERICAN CAR & FOUNDRY
AVION • CARTER CARBURETOR • SHIPPERS' CAR LINE • W-K-M

Write in No. 207 on Reader Service Card at start of Product Preview Section

NEW, HIGH CAPACITY COMPRESSOR BY STRATOS

The PCM3-4—a compact 3000 psi compressor delivering 12 scfm.

Ideal for ground support and airborne applications, this compact new compressor delivers 12 scfm of air at 3000 psi. A four stage compressor designed in a 90°V shape, the unit weighs less than 39 pounds; its envelope measures only 13.5 inches in diameter and 18½ inches in length. Self cooling by an integral fan plus an efficient inter-cooling system are provided. An unloader valve and a pressure regulator are incorporated for automatically controlling output and inlet pressure. The compressor can be operated with an unpresurized inlet. The PCM3-4 is adaptable to turbine, hydraulic or electric drive.

SPECIFICATIONS

COMPRESSOR

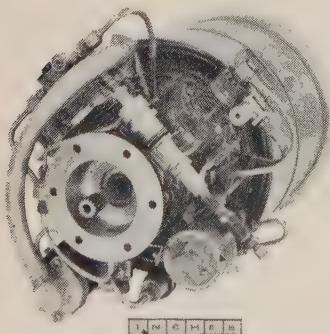
Discharge Pressure Maximum Rated . . . 3000 psig
Delivery Capacity Rated 12 scfm
Compression Stages 4
Speed Rated 4000 rpm
Driving Horsepower 13.5
Inlet Pressure 14.7 psia
Inlet Temperature 59°F

CONTROLS

Cut-in—Cut-out Differential 300 psi
Cut-in Pressure 2800 psi
Cut-out Pressure 3100 psi
Pressure Relief 3300 psi

ENVIRONMENTAL

Low Temperature —65°F
High Temperature +165°F



STRATOS



A division of Fairchild Engine and Airplane Corporation

Main plant:
Orinoco Drive,
Bay Shore, L. I., N. Y.

Western Branch:
1800 Rosecrans Ave.,
Manhattan Beach, Calif.

Write in No. 208 on Reader Service Card
308

DATA PREVIEW

FREQUENCY STANDARD—Three catalogs on tuning fork frequency standards with application to power-frequency-sensitive instruments, such as radar, timing devices, and airborne fire control and navigation systems, have been issued by Hathaway Instrument Div., Hamilton Watch Co., Dept. S/A, 5800 E. Jewell Ave., Denver 22, Colo. Catalog 52790 covers a 400-cycle unit, Catalog 55858, a 6250-cps device, and Catalog 55906, a unit that covers the 200 to 6400-cps range.

Write in No. 315 on Reader Service Card

PRESSURE CALIBRATION—A 4 page bulletin, #8018, describing systems that measure or calibrate pressures has been published by Consolidated Electrodynamics Corp., Dept. S/A, 360 Sierra Madre Villa, Pasadena, Calif. Photos and a block diagram help explain systems for calibration benches, wind tunnel pressure measurement, propellant utilization system exercisers, liquid level control, determination of pressure ratios, ramjet engine testing, and calibration of pressure switches, aneroid barometers, and pressure pickups.

Write in No. 316 on Reader Service Card
more on page 310

LOOK to the LEE HOTELS

Superb accommodations,
full value and "snap-to" service



Beverly Hills
THE BEVERLY CARLTON

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GRaystone 4-3600 in San Francisco
HOLlywood 5-1131 in Los Angeles
MAin 3-6688 in Seattle
or Teletype LA 1840 in Los Angeles

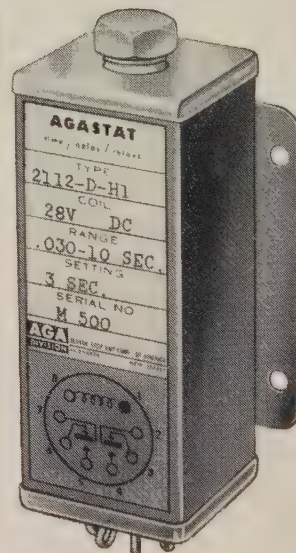
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NOW!

MINIATURE AGASTAT®

time/delay/relay

MEASURES ONLY 4" x 1½" x 1½"



The Miniature Agastat time delay relay is a space-saving answer to aircraft, missile and computer problems. You get all these valuable features in one small package:

- Easily adjusted timing ranges as short as .030 seconds.
- Repeat accuracy of $\pm 5\%$.
- Time delay on energizing or de-energizing.
- For DC or AC operation.
- Hermetically sealed or dust-proof housings.

Write today for the full details on the new miniature Agastat. Dept. A36-119.

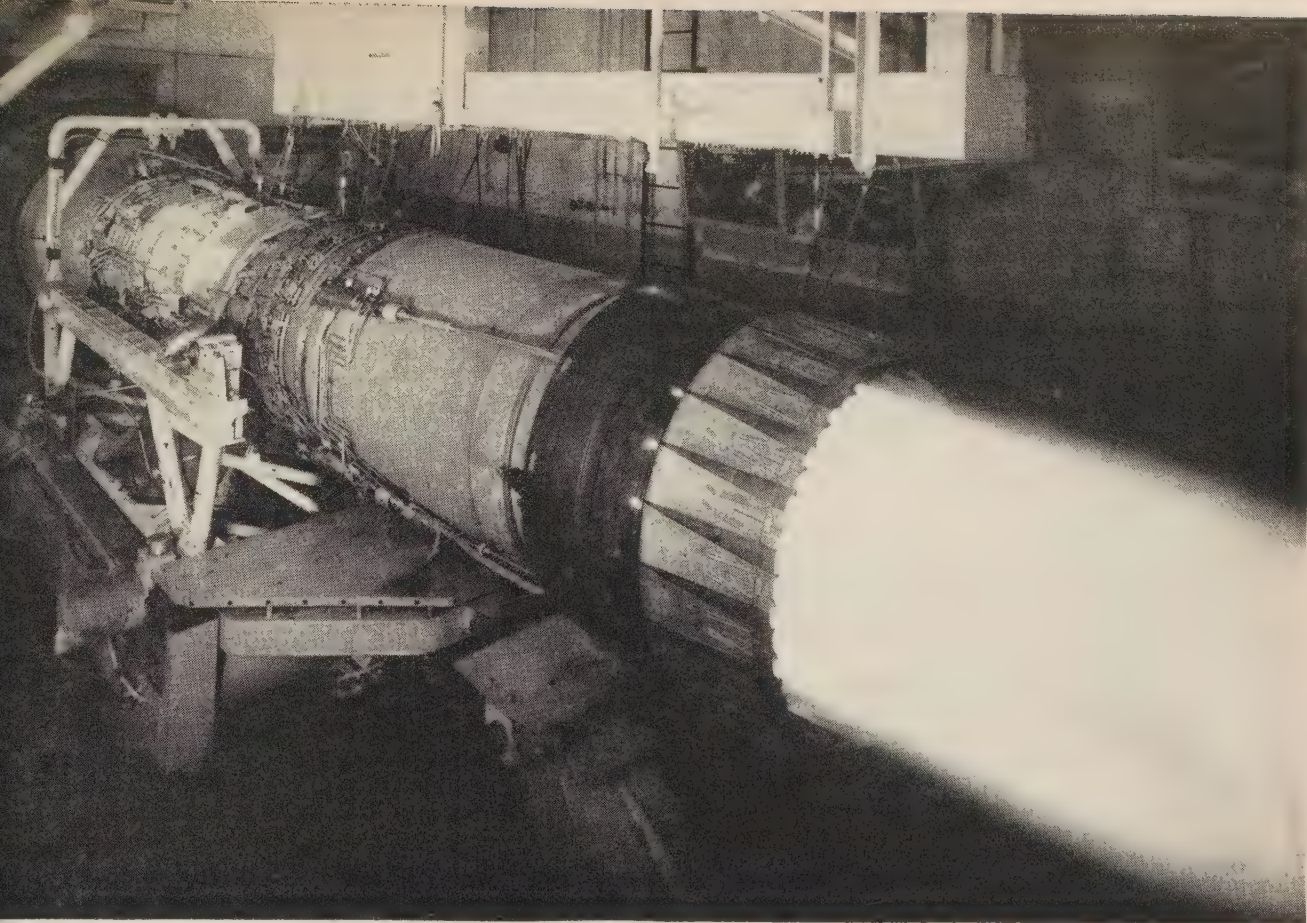


ELASTIC STOP NUT CORPORATION OF AMERICA

1027 Newark Avenue, Elizabeth, N. J.

Gasaccumulator Co., (Canada) Ltd., 12 Gower Street, Toronto 16, Ontario

Write in No. 210 on Reader Service Card at start of Product Preview Section
SPACE/AERONAUTICS



1000 mph plus—standing still...

Honeywell Tape Systems Permit Uninterrupted Tests of F-104 Starfighter Engines

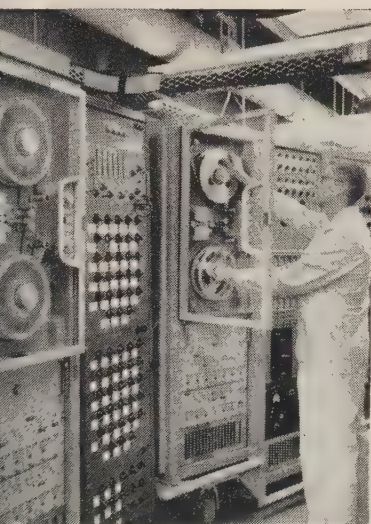
Honeywell Series 3170 Magnetic Tape Systems enable General Electric to analyze the performance of their J79 jet engines for supersonic F-104 Starfighters at rated thrusts . . . and without interruptions.

Engines may "travel" thousands of miles during the tests, which are held at G.E.'s Evendale, Ohio, Flight Propulsion Division Laboratories. Stresses, vibration, fuel and air pressures and critical temperatures are recorded simultaneously by Honeywell wide tape, 26-channel, FM systems.

The Honeywell equipment's high capacity and the unique device for switching all data inputs from one tape transport to another, make it possible to record an entire test without interruptions or loss of data. This eliminates downtime and helps to reduce test costs.

. . .

High recording capacity is only one of many mechanical and electronic advantages you get with a Honeywell Series 3170 Tape System. Contact your Honeywell field engineer for full details on a system that will meet your specific needs. MINNEAPOLIS-HONEYWELL, 10721 Hanna St., Beltsville, Md.



Engineer removes fully-recorded reel
test data after switching all inputs to
and transport without interrupting test.

Honeywell



First in Control

SINCE 1885

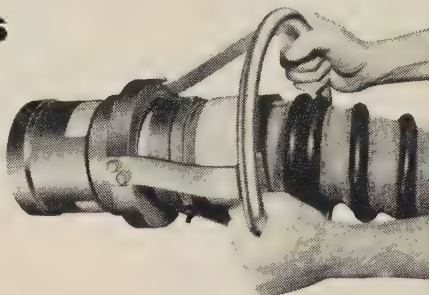
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ON MARK COUPLINGS

**PUSH TO CONNECT—
PULL TO DISCONNECT—**

ON MARK'S

*New Ground
Starter
Coupling for
Commercial
Jet Aircraft*



Rugged construction and superior features set On Mark's new series 5-1100 Ground Starter Coupling apart from ordinary couplings of this type. Push to connect... pull to disconnect... operation is that simple. No turning of parts is necessary to assure a positive lock. Six rugged locking fingers give a broad gripping surface in contact with the adapter. Visual indicator tells at a glance when coupling is in locked or unlocked position.

Valve automatically closes instantaneously on disconnect to prevent whipping of the duct under operating pressure. Low heat transfer rate allows coupling handling immediately after start even with bare hands.

For full information please write to:

ON MARK COUPLINGS, INC.
4440 York Boulevard, Los Angeles 41, California
Telephone CLinton 4-2278

Representatives: Airsupply Company, Beverly Hills, Calif.; Aero Engineering Company, Mineola, Long Island, N.Y.—Divisions of The Garrett Corporation; The Garrett Corporation of Canada, Ltd., Montreal, Canada.



Write in No. 212 on Reader Service Card at start of Product Preview Section

Joclin Teflon* Tapes



**FREE
6-page
Fluorolint†
Tape
Brochure**

Most comprehensive line of fluorocarbons tapes on the market today.
Pressure-sensitive and bondable.
Cast film • Skived • Extruded sintered and unsintered.
Teflon fiberglass • Teflon metal combinations.

*Trademark DuPont †Trademark Joclin

The **Joclin** manufacturing company 22 Lufbery Avenue
Wallingford, Connecticut

Write in No. 213 on Reader Service Card at start of Product Preview Section

DATA PREVIEW

TOGGLE SWITCH—A data sheet describing precision pull-to-unlock toggle switches has been issued by Minneapolis-Honeywell Regulator Co., Micro Switch Div., Dept. S/A, Freeport, Ill. Identified as data sheet 160, there are included photographs, dimension drawing, characteristics, electrical rating and price information.

Write in No. 317 on Reader Service Card

SOUND ISOLATION ROOMS—Sound isolation rooms designed to provide controlled acoustical environments is the subject of a data sheet by Industrial Acoustics Co., Inc., Dept. S/A, 341 Jackson Ave., New York 54, N. Y. Applications include product research and development, quality control and product testing, acoustical laboratory rooms and housings for noise production equipment.

Write in No. 318 on Reader Service Card

TRANSFORMERS—Veri-miniature transistor transformers in hermetically sealed construction are discussed in a 24 page catalog by Microtran Co., Inc., Dept. S/A, 145 E. Mineola Ave., Valley Stream, N.Y.

Write in No. 319 on Reader Service Card

BEARINGS—Double row ball bearings, including open, shielded and snap ring types, are described in bulletin 111 issued by Hoover Ball & Bearing Co., Dept. S/A, 5400 S. State Rd., Ann Arbor, Mich. Dimension and load specifications for both light and medium series are provided together with a discussion of other application considerations.

Write in No. 320 on Reader Service Card

BLIND RIVETS—a 4-page illustrated folder, form 8-457, describing aluminum self-plugging blind rivets is available from Huck Mfg. Co., Dept. S/A, 2480 Bellevue Ave., Detroit 7, Mich. The folder illustrates typical applications with cross-section line drawings, material specifications, shear and tension strength values, hole size recommendations and shop practice notes.

Write in No. 321 on Reader Service Card

WELDING—The Aircomatic gas-shielded metal-arc process of welding mild and low alloy steels with carbon dioxide as a shielding gas has been described in a 24-page booklet by Air Reduction Co., Inc., Dept. S/A, 150 E. 42nd St., New York 17, N.Y. Catalog ADE 882 covers both the conventional CO₂ and Dip Transfer CO₂ processes and includes information on fundamentals, practical application, and welding equipment.

Write in No. 322 on Reader Service Card

more on page 312



An important new Janitrol resource:

Janitrol joins Midland-Ross

In November Midland-Ross Corporation purchased Surface Combustion Corporation, including the Janitrol Aircraft Division. The merger enables Janitrol to bring a new depth of engineering talent, resources, and systems management skills to the missile and aircraft industry. Midland-Ross is a leading builder of automotive frames and power brakes, and engineered atmosphere control equipment for industry.

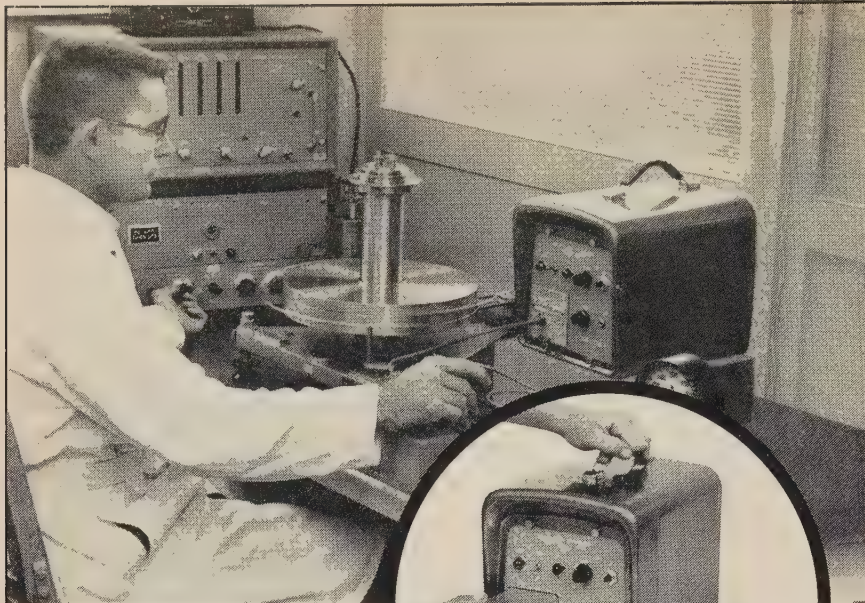
You probably will not notice the change; the same sales engineers will call on you and you'll deal with the same people at Janitrol's modern new plant. Janitrol engineers will continue to help meet your requirements—but the scope of available engineering experience will be increased. The group has simply moved into a bigger "house" to serve you better.

When your plans call for heat exchangers, pneumatic controls, duct supports and couplings, combustion and liquid heating equipment for aircraft, missiles and ground support—ask Janitrol for a proposal.

Janitrol Aircraft, 4200 Surface Road, Columbus 4, Ohio.

JANITROL AIRCRAFT
a division of MIDLAND-ROSS CORPORATION

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ONLY *wiancko* offers a portable secondary standard with digital readout

Check these exclusive features:

- ✓ Permits direct parameter measurements and calibration of transducers (pressure, force and accelerometers) in field, plant or laboratory.
- ✓ x2 and x4 plug-in frequency multiplier, coupled with bandwidth adjust provides greater accuracy due to increased resolution and real data capability—speedier testing and checkout.
- ✓ Readily interchangeable plug-in units for absolute, gage and differential pressure heads—ranges 5 to 10,000 psi.
- ✓ Head adapter permits use of Wiancko force rings, accelerometer or pressure pickups—500 feet distant from Standard.

Accuracy: ± 0.05 percent full scale; ranges 0-2500 psi
 ± 0.08 percent full scale; ranges 3000-10,000 psi

For more information write for Product Bulletin 106A.

WIANCKO
ENGINEERING COMPANY



255 North Halstead Avenue • Pasadena, California

Precision with lasting reliability

Write in No. 215 on Reader Service Card at start of Product Preview Section

DATA PREVIEW

VOLTAGE REGULATORS—Application, description, selection, weights, dimensions, and connection diagrams are given in a 60-page illustrated booklet covering voltage regulators. The publication describes GE's dry type and liquid filled voltage regulators 60 and 400 cycles and is available from the Voltage Regulator Production Section, Dept. S/A, Pittsfield, Mass.

Write in No. 323 on Reader Service Card

BEARINGS—Information about the deep-groove ball bearings in many types and sizes for industrial applications are discussed in bulletin 110 by Hoover Ball & Bearing Co., Dept. S/A, 5400 S. State Rd., Ann Arbor, Mich. Dimensions, loads and other application data are included.

Write in No. 324 on Reader Service Card

ELECTRICAL CONNECTORS—Spacecraft and missiles are pictured in color in a 12 page brochure by Burndy Corp., Dept. S/A, Norwalk, Conn. Photographs and engineering drawings illustrate principal connector types used in missiles and ground-control equipment. Environmental and performance standards of connectors for missile electrical and electronic circuits are reviewed.

Write in No. 325 on Reader Service Card

RECORDING INSTRUMENTS—A general catalog, bulletin 1310, describing a line of dynamic-measuring and recording instruments including oscillographs, data amplifiers and bridge balances, vibration measuring equipment, and power supplies has been prepared by Consolidated Electrodynamics Corp., Dept. S/A, 360 Sierra Madre Villa, Pasadena, Calif. A summary of specifications for CEC standard galvanometers is also included.

Write in No. 326 on Reader Service Card

COPPER ALLOY—Data and Specification Sheet 135 describing a copper-phosphorous alloy that does not require flux on copper-to-copper joints is available from American Brazing Alloys Co., Dept. S/A, P.O. Box 11, Pelham, N.Y. Phos Sil O starts to melt at 1300 deg F has a brazing range of 1350 to 1500 deg F, and can also be used on brass or bronze.

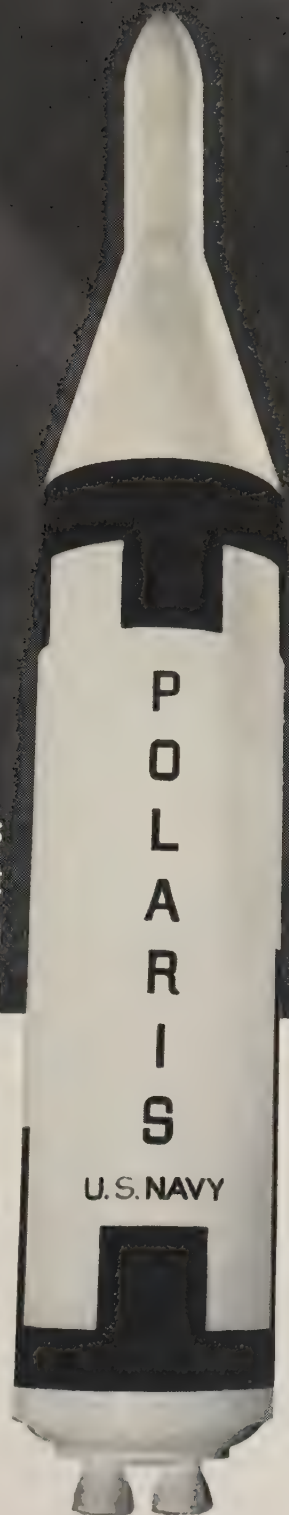
Write in No. 327 on Reader Service Card

TEMPERATURE CONTROLS—Nineteen midjet and miniature thermostat controls are described in brochure MC-182 issued by Fenwal Inc., Dept. S/A, Pleasant St., Ashland, Mass. Dimensions, temperature range, electrical ratings and available modifications are given for each unit.

Write in No. 328 on Reader Service Card

The Navy's
deterrent
missile system
will be

READY
THIS
YEAR!



The day of the mobile missile base is close at hand. Four of the Navy's nuclear-powered, ballistic-missile subs have already been launched. The missile they'll carry—the Lockheed-built Polaris—is undergoing its final tests. This year, America will have a deterrent weapon that is safe from surprise.

LOCKHEED

MISSILES & SPACE DIVISION

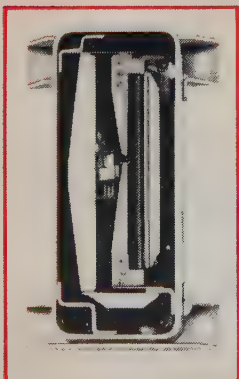
The most precise, sturdiest thermal relay ever built... best for missile applications



...from the leader in thermal relay design!

Now, for missile environments and for all applications where greater precision is necessary, G-V Controls offers the revolutionary new PT Thermal Relay—the most **precise** thermal relay ever built!

And the PT's **sturdiness** is unequalled in thermal relays. It withstands missile vibration and shock far better than any other thermal relay.



SPECIFICATIONS

Time Delay: 3 to 60 seconds (Factory Set)

Setting Tolerance: $\pm 5\%$ ($\pm \frac{1}{4}$ sec. min.)

Temperature Compensation: Within $\pm 5\%$ over -65°C. to $+125^{\circ}\text{C.}$ range ($\pm \frac{1}{4}$ sec. min.)

Heater Voltages: 6.3 to 115 v. for delays up to 12 sec.; 6.3 to 230 v. for longer delays.

Power Input: 4 watts. Rated for continuous energization at 125°C.

Contacts: SPST, normally open or normally closed. Rated 2 amps. resistive at 115 v. AC or 28 v. DC.

Write for Product Data Bulletin #PD-1015

Insulation Resistance: 1,000 megohms

Dielectric Strength: 1000 v. RMS at sea level. 500 v. RMS at 70,000 ft.

Vibration: Operating or non-operating, 20 g up to 2000 cps

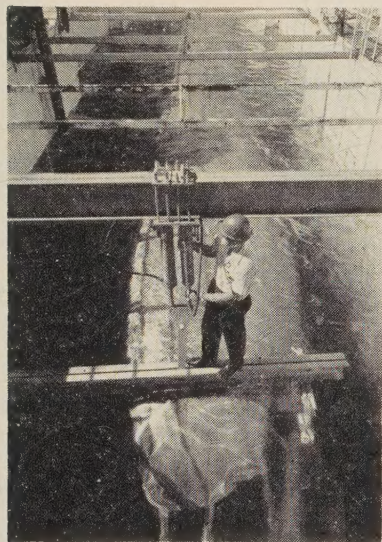
Shock: Operating or non-operating, 50 g for 11 milliseconds

Unidirectional Acceleration: 10 g in any direction changes delay by less than 5%, 50 g by less than 10% with proper orientation.

Weight: 2 to $2\frac{1}{4}$ ounces.

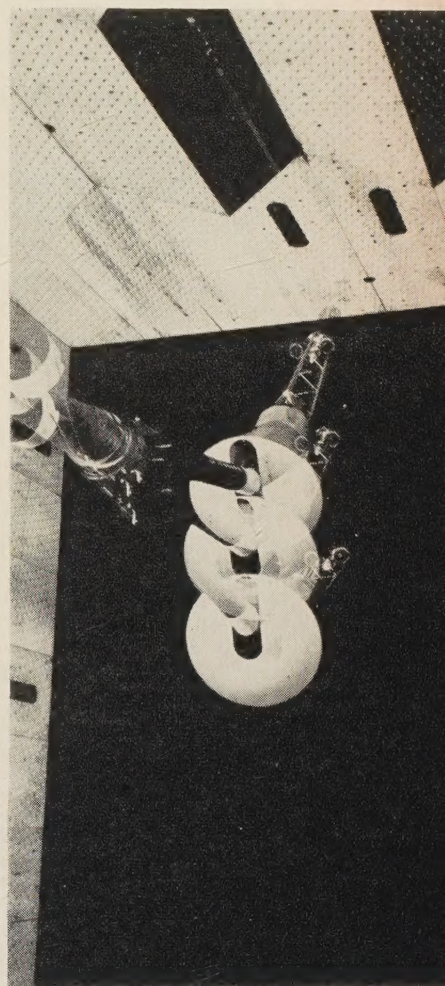
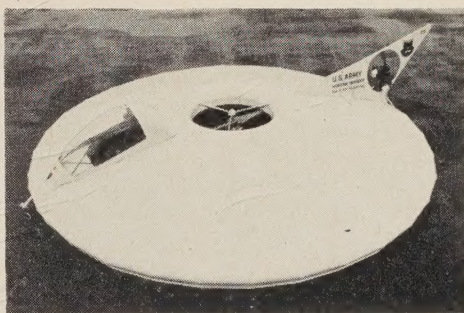
G-V CONTROLS INC.
Livingston, New Jersey



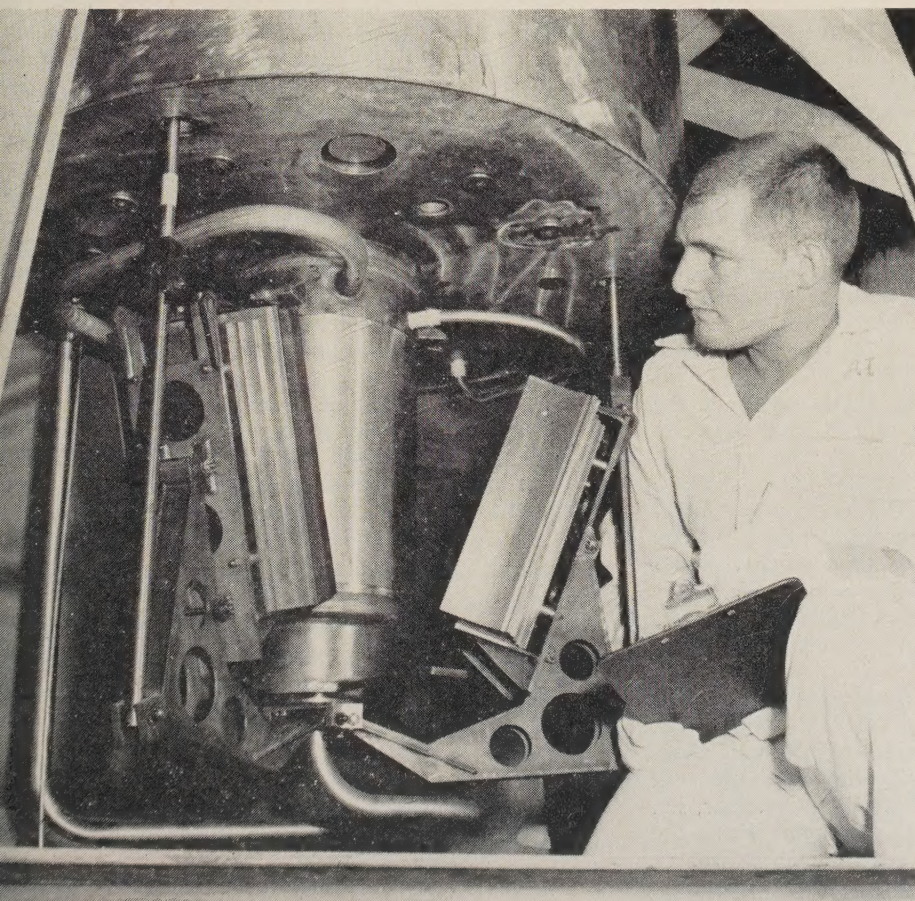


CONVAIR 880 fuselage in test tank (above) has been submitted to 56,000 simulated airline flights. Below: Cylindrical container holds core of 220-lb Snap II nuclear reactor for space missions.

X-3 EXPERIMENTAL ground effect craft was designed by Princeton U. researchers under Army contract. In the center duct, a vertically mounted 44-hp engine turns a horizontal prop. A five-hp engine powers the prop in the fin, which swings through a 180-deg arc in the horizontal plane. Thirty-two vanes in a slot ringing the craft's base provide directional control.



STABILITY of the Mercury capsule in the critical Mach 0.5-1.5 transonic speed range was tested in Arnold Engineering Development Centers wind tunnel. A 32 per cent scale model was mounted on a movable support that was then tilted to simulate the flight attitudes under various trajectory conditions. This multiple-exposure photograph also shows some clear detail of the escape tower attached to the capsule. This tower supports a solid propellant rocket that lifts the capsule from the booster in case of a malfunction. Once a safe altitude is reached, the tower drops off and the capsule parachutes to earth.





readers' round table

Basic units of the metric system

by Carmine De Angelis,

Aeronautical Design Engineer, Republic Aviation Corp.

Hundreds of our readers have expressed their preference for the metric system in "ballots" to the American Standards Association recently. For those not familiar with the metric system, this contribution gives the basic units of the system and shows their simple relationships.

THE DECIMAL metric system has three basic units: meter (for length), gram (for mass), and liter (for capacity). These units have a constant, simple interrelation so that—for all practical purposes—the volume of one kilogram, or liter, of water equals one cubic decimeter.

The basic unit of length is the *meter* (m). The other length units are: *myriameter* (Mm) = 10 km = 100 hm = 1000 dkm = 10,000 m; *kilometer* (km) = 10 hm = 100 dkm = 1000 m; *hectometer* (hm) = 10 dkm = 100 m; *dekameter* (dkm) = 10 m; *decimeter* (dm) = 0.1 m; *centimeter* (cm) = 0.01 dm = 0.01 m; *millimeter* (mm) = 0.1 cm = 0.01 dm = 0.001 m.

As you can see, the length units increase linearly by powers of 10—every unit is 10 times that of the next-lower unit.

Any metric-system unit is transformed by moving the decimal point to the left to get the desired new unit order. To transform a length unit of a certain order into a unit 10, 100, 1000, etc., times lower, move the decimal point to the *right* by one, two, three, or more places in accordance with the magnitude of displacement to the order desired. For example; m 4.2 = mm 4200; km 0.064 = dm 640; Mm 0.8326 = cm 832600. To transform a length unit of certain order into a unit 10, 100, 1000, or more times higher, move the decimal point to the *left* by one, two, three, or more places in accordance with the magnitude or displacement to the order desired. For example, mm 324120 = hm 3.24120; m 68 = Mm 0.0068; cm 428.62 = dkm 0.42862.

The basic unit of area in the metric system is the *square meter* (m²), which is a square with sides one meter in length. Other units of area are: *square myriameter* (Mm²) = 100 km² = 100,000,000 m²; *square kilometer* (km²) = 100 hm² = 10,000 dkm² = 1,000,000 m²; *square hectameter*, or hectare, (hm²) = 100 dkm² = 10,000 m²; *square dekameter*, or are (dkm²) = 100 m²; *square decimeter* (dm²) = 0.01 m²; *square centimeter* (cm²) = 0.01 dm² = 0.0001 m²; *square millimeter* (mm²) = 0.01 cm² = 0.0001 dm² = 0.000,00 m².

The area units increase linearly by powers of 100—every unit is 100 times that of the next-lower order. Since the unit increase is by powers of 100, unit transformation follows the same rules as with length units but the move of the decimal point will be by two, four, six, or more places. The number of places by which the decimal point is moved is always a multiple of two.

The basic unit of volume is the *cubic meter* (m³), which is a cube with sides one meter in length. Other units of volume are: *cubic myriameter* (Mm³) = 1000 km³ = 10¹² m³; *cubic kilometer* (km³) = 1000 hm³ = 1,000,000 dkm³ = 10⁹ m³; *cubic hectameter* (hm³) = 1000 dkm³ = 1,000,000 m³; *cubic dekameter* (dkm³) = 1000 m³; *cubic decimeter* (dm³) = 0.001 m³ = 0.000,001 m³; *cubic millimeter* (mm³) = 0.001 cm³ = 0.000,001 dm³ = 0.000,000,001 m³.

The volume units increase linearly by powers of 1000. Therefore, in the unit transformation the move of the decimal point in this case is by three, six, nine, or more places. The number of places by which the decimal point is moved is always a multiple of three.

The basic unit of capacity is the *liter* (l), which equals one cubic decimeter. It is the volume occupied by the mass of one kilogram of pure water at four degrees C under normal atmospheric pressure. Other units of capacity are: *kiloliter* (kl) = 1 hl = 100 dkl = 1000 l; *hectoliter* (hl) = 10 dkl = 100 l; *dekaliter* (dkl) = 10 l; *deciliter* (dl) = 0.1 l; *centiliter* (cl) = 0.1 dl = 0.01 l.

The capacity units as shown increase linearly by powers of 10. Therefore, unit transformation follows the rules given for the measure of length.

The basic unit of weight is the *gram* (gm). It equals the mass of one cubic centimeter of distilled water at four degrees C at sea level and 45 deg latitude. Other units of weight are: *metric ton* (t) 10 q = 100 Mg = 1,000,000 gm; *quintal* (q) = 10 Mg = 100 kg = 100,000 gm; *myriagram* (Mg) = 10 kg = 100 hg = 1000 dg = 10,000 gm; *kilogram* (kg) = 10 hg = 100 dkg = 1000 gm; *hectogram* (hg) = 10 dkg = 100 gm; *dekagram* (dkg) = 10 gm; *decigram* (dg) = 0.1 gm; *centigram* (cg) = 0.1 dg = 0.01 gm; *milligram* (mg) = 0.1 cg = 0.01 dg = 0.001 gm.

The weight units increase linearly by powers of 10. Unit transformation again follows the rules given for measures of length.

The specific weight of a substance is the ratio between the mass of the substance and the mass of an equal volume of distilled water at four degrees C. It is used to establish the mass of a substance of given volume or the volume of a substance of given mass:

$$y = W/V, V = W/y, W = Vy,$$

where *W* is weight; *V*, volume, and *y*, specific weight of a given mass.

If the volume is in cubic centimeters, the weight is in grams; if the volume is in cubic decimeters, the weight is in kilograms; and if the volume is in cubic meters, the volume is in tons.

Contributions to this department may be on any subject, technical or nontechnical, about which readers would like to air their views. Names and professional affiliations will be withheld on request.

TACTICAL COMMUNICATIONS:

* CRIMEA 1854

... 'Forward the Light Brigade!
Charge for the guns!' he said.
Into the valley of Death
Rode the six hundred.

* ... Was there a man dismay'd?
Not tho' the soldier knew
Someone had blunder'd.
Theirs not to make reply,
Theirs not to reason why,
Theirs but to do or die.
Into the valley of Death
Rode the six hundred.

... Cannon to right of them,
Cannon to left of them,
Cannon behind them
Volley'd and thunder'd;
Storm'd at with shot and shell,
While horse and hero fell,
They that had fought so well
Came thro' the jaws of Death ...
... All that was left of them,
Left of six hundred.

ALFRED LORD TENNYSON



RICHARD CATON WOODVILLE, JR. "Charge of the Light Brigade." Parker Gallery, London

Blundering tactical command in this age of quick-reaction military operations may not be similarly immortalized. Today, instantaneous and completely reliable Electronic Communications, both voice and tactical data link, provide the continuous two-way intelligence that precludes the blunders which sealed the fate of the Light Brigade.

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One of a series of advertisements depicting historic incidents in military communications through the ages


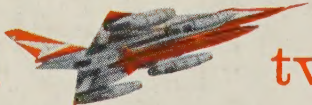
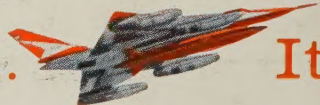


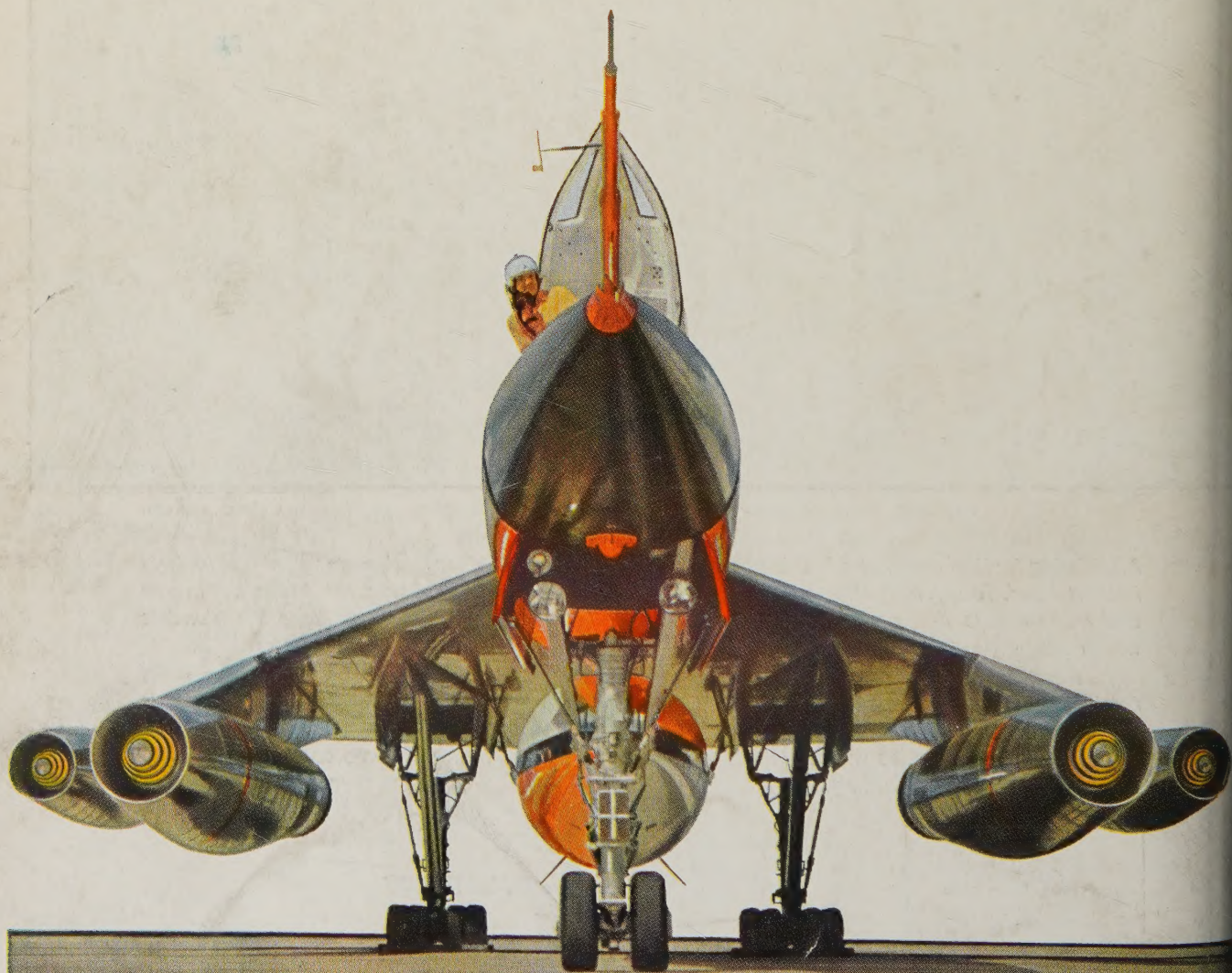
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